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INTERIM REPORT - UPPER OTTAWA
STREET LANDFILL SITE STUDY,
REFERENCE PAPER 1 :
EFFECTS ON GROUNDWATER &
SURFACE WATER ...

THE EFFECTS OF THE
UPPER OTTAWA STREET
LANDFILL SITE

on

GROUNDWATER AND SURFACE WATER

February, 1982

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REFERENCE 1

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UNITS OF MEASUREMENT

Regular Chemistry Parameters

Chlorides	mg/l or ppm
Alkalinity	mg/l or ppm as $CaCO_3$
BOD 5	mg/l or ppm oxygen
COD	mg/l oxygen ppm
pH	pH units 0 - 14 acidic ← 7 neutral → alkaline
Conductivity	µmho/cm
Total Solids	mg/l or ppm
Dissolved Solids	mg/l or ppm
Suspended Solids	mg/l or ppm
Ammonia	mg/l or ppm nitrogen
Nitrite	mg/l or ppm nitrogen
Nitrate	mg/l or ppm nitrogen
Total Kjeldhal	mg/l or ppm nitrogen
Phosphorous (total)	mg/l or ppm
Soluble Phosphorous	mg/l or ppm phosphorous

Heavy Metals

Total Iron	mg/l or ppm
Chromium	mg/l or ppm
Cadmium	mg/l or ppm
Aluminum	mg/l or ppm
Zinc	mg/l or ppm
Nickel	mg/l or ppm
Arsenic	mg/l or ppm
Lead	mg/l or ppm
Manganese	mg/l or ppm
Copper	mg/l or ppm

Bacteria

Total Coliforms	/100 ml
Background	/100 ml
Fecal Coliforms	/100 ml
Fecal Streptococci	/100 ml
Fecal Coliform: Fecal Streptococci:	ratio

Organic Scan (Pesticides, Herbicides, Insecticides, Fungicides)

all trace elements	µg/l or ppb
PCB's	µg/l or ppb
Phenols	µg/l or ppb

mg/l	milli grams per litre	ppm
µg/l	micro grams per litre	ppb
ppm	parts per million	
ppb	parts per billion	

INTRODUCTION

Redhill Creek flows directly adjacent to the northern face of the Upper Ottawa Street Sanitary Landfill Site.

The Upper Ottawa Street sanitary landfill site is located in Hamilton, Ontario. The landfill site was accepting domestic and industrial waste since its opening. The lifespan of the landfill was just over 20 years. During the latter part of the operation, the landfill site was also used for the disposal of liquid industrial wastes and the operation of a heavy metal fixation plant. The landfill was closed to the public in July of 1980 but was still accepting wastes. The final closure date was October of 1980. The application of a final cover at the landfill site is still in the process at the time of this report.

Upon a visual inspection of the site, it can be quite clearly seen that the toe of the landfill is encroaching upon Redhill Creek and at several points forms the streambank for the creek. At the time of the report writing, erosion protection was being installed. Leachate springs and runoff from the landfill have been reaching Redhill Creek for many years (H.R.C.A. 1975, MOE,1978).

Redhill Creek has a total drainage area of 21.2 square miles, and the entire watershed is being rapidly urbanized (MOE, 1978). Redhill Creek originates near Upper James and Stone Church Road. The creek has been re-routed directly upstream from the landfill through an underground drain between Upper Sherman and Upper Ottawa Streets to allow for urbanization. Redhill creek re-appears approximately 650 feet East of Upper Ottawa Street. The creek flows along the northern face of thelandfill site (approx. 3,000 ft.) to Redhill Creek Pond. It then flows over the edge of the escarpment at Mount Albion Falls. The creek then follows Redhill Creek Valley where it discharges into the Hamilton Bay near Burlington Street and Woodward Avenue.

REASONS

The Upper Ottawa Street Landfill Study Committee requested the Ministry of the Environment to prepare a document containing the results and analyses of all work done on the site. The purpose of this document is to assist the Committee in:

a. investigation of possible health hazards and related environmental issues;
b. determining the effect of the landfill site on ground water;
c. and determining the effect of the landfill site on surface water.

SURVEY METHODS

Sampling stations were selected as shown in Figure 1 for the ground water sites and Figure 2 for the surface water sites.

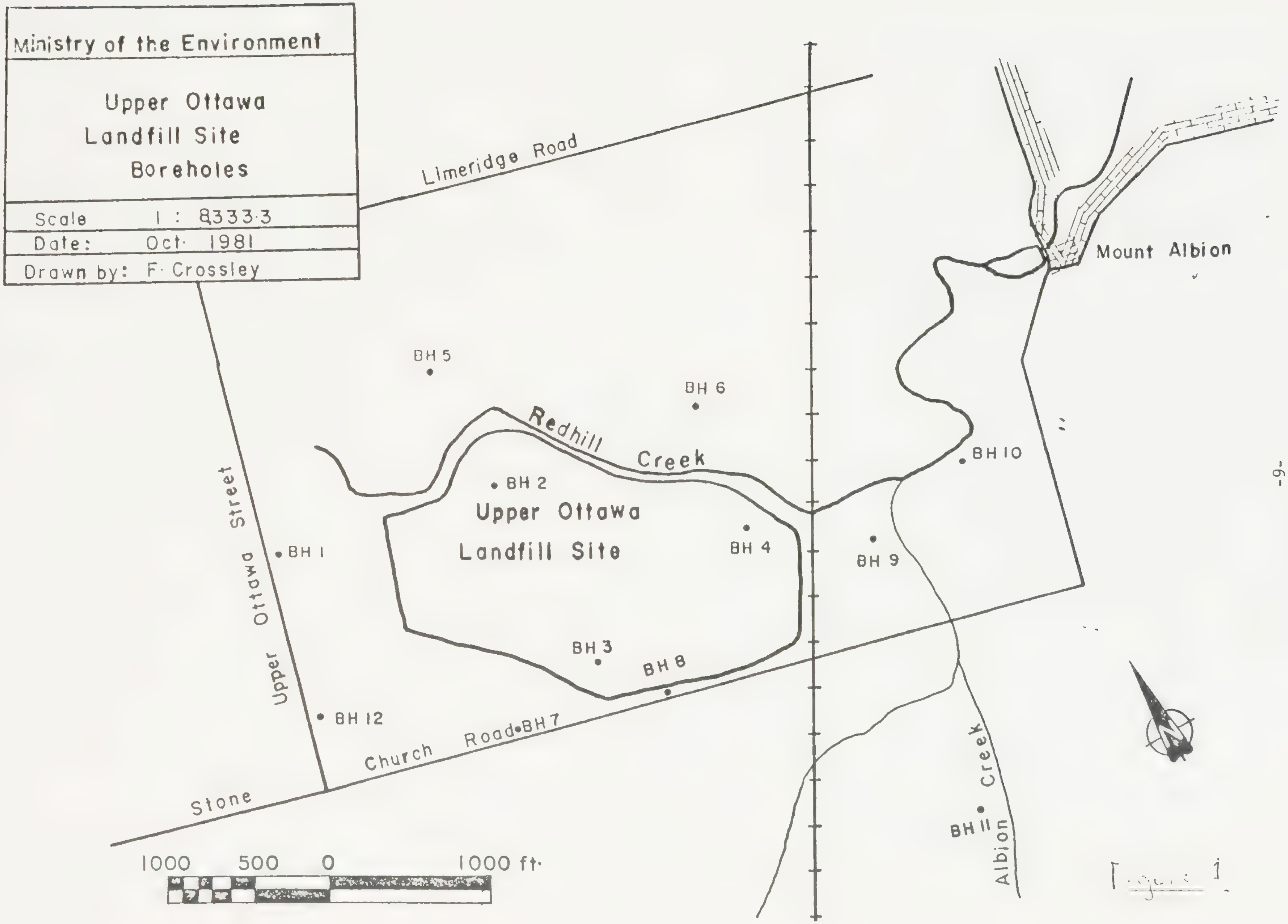
The groundwater locations were selected by Gartner Lee Associates Ltd. Each borehole at the landfill site has a groundwater monitor installed. In each borehole, a piezometer and standpipe were installed. A piezometer is a well that samples a specific section of the aquifer. The tube is open-ended at the top (however it is capped to prevent foreign materials from entering) and either open-ended or is equipped with an intake screen at the bottom. All the piezometers at the Upper Ottawa Landfill site have an 18 inch long intake screen (Gartner Lee Associates). In some of the boreholes multiple piezometers were set with the use of a second hole (Gartner Lee Assoc.). This nest of piezometers allows water to be sampled at varying depths. The height of the static water level in the piezometer indicates the piezometric pressure head at the specific depth of screen and can be used to delineate vertical hydraulic gradients. The piezometers were completed into bedrock at the sanitary landfill site (Borehole Logs, GLA,1980). A standpipe is a vertical tube inserted into the ground down to a chosen point. The tube is the same as a piezometer except the tube is slotted from end to end. The height of the static water level in the standpipe indicates the water table. The standpipes were completed into garbage, overburden, and bedrock. Both piezometers and standpipes can also be used for obtaining groundwater samples.

The surface water locations were selected by the MOE and Gartner Lee Assoc. Gartner Lee Assoc. duplicated many of the MOE sites used in the 1978 report. The RH series of stations is the MOE site locations while the SW series is the Gartner Lee Assoc. Sites RH15 (SW6), and RH14 (SW4) are used as upstream controls for background levels in Redhill Creek. RH12 (SW5) was used as a background control and a monitor of inputs by the tributary, Albion Creek. SW3 is used as a mid point on RHC between

the immediate upstream site RH14 (SW4) and the immediate downstream site RH13 (SW2). Sites RH13 (SW2), SW1, RH11, and SW7 are downstream stations. These stations show the effects of the landfill site on Redhill Creek. Redhill Creek (RH11) at Mount Albion Falls is a regular monitoring station for the MOE (since 1979) and was selected in the survey to allow for contribution to the creek from any contaminated groundwater in the area (MOE 1978).

RH16 and RH17 are leachate samples. RH16 is leachate that collects in a low spot (Black Hole) in the NE corner of the landfill. There is a manmade berm with a core of clay material to pond the runoff and leachate. At the time of the report writing, the ponded area has been drained by pumping the water to the sanitary sewer on Stone Church Road. RH17 is a leachate spring that enters directly into Redhill Creek. RH18 is surface runoff and leachate from the sanitary landfill site. The runoff is to the south side of the landfill. At the time of the report writing, french drains and a toe collector system were being installed to prevent the runoff from moving towards the creek.

The sampling was done be personnel at the Ministry of the Environment and Gartner Lee Assoc. The MOE used the Toronto MOE lab facilities for analysis of data. Gartner Lee Assoc. obtained their data analysis from the Toronto MOE lab facilities and the Regional Municipality of Hamilton-Wentworth lab facilities. The sampling was done at random throughout the year except for the routine monthly monitoring at Mount Albion Falls (RH11).



Ministry of the Environment

Upper Ottawa
Landfill Site
Boreholes

Scale 1 : 8333.3
Date: Oct. 1981
Drawn by: F. Crossley

Figure 1

TABLE 1

SURFACE WATER SITE DESCRIPTIONS

SW 1	Upstream of Redhill Pond
SW 2-RH13	Redhill Creek below landfill site
SW 3	Redhill Creek between Upper Ottawa and CNR tracks
SW 4-RH14	Redhill Creek at Upper Ottawa Street
SW 5-RH12	Albion Creek at Stone Church Road
SW 6-RH15	Redhill Creek at Upper Sherman Street
SW 7	Redhill Creek 1000 feet from Albion Falls
RH11	Redhill Creek at Mount Albion Falls
RH16	Leachate runoff from landfill site
RH17	Leachate spring
RH18	Surface runoff from landfill site

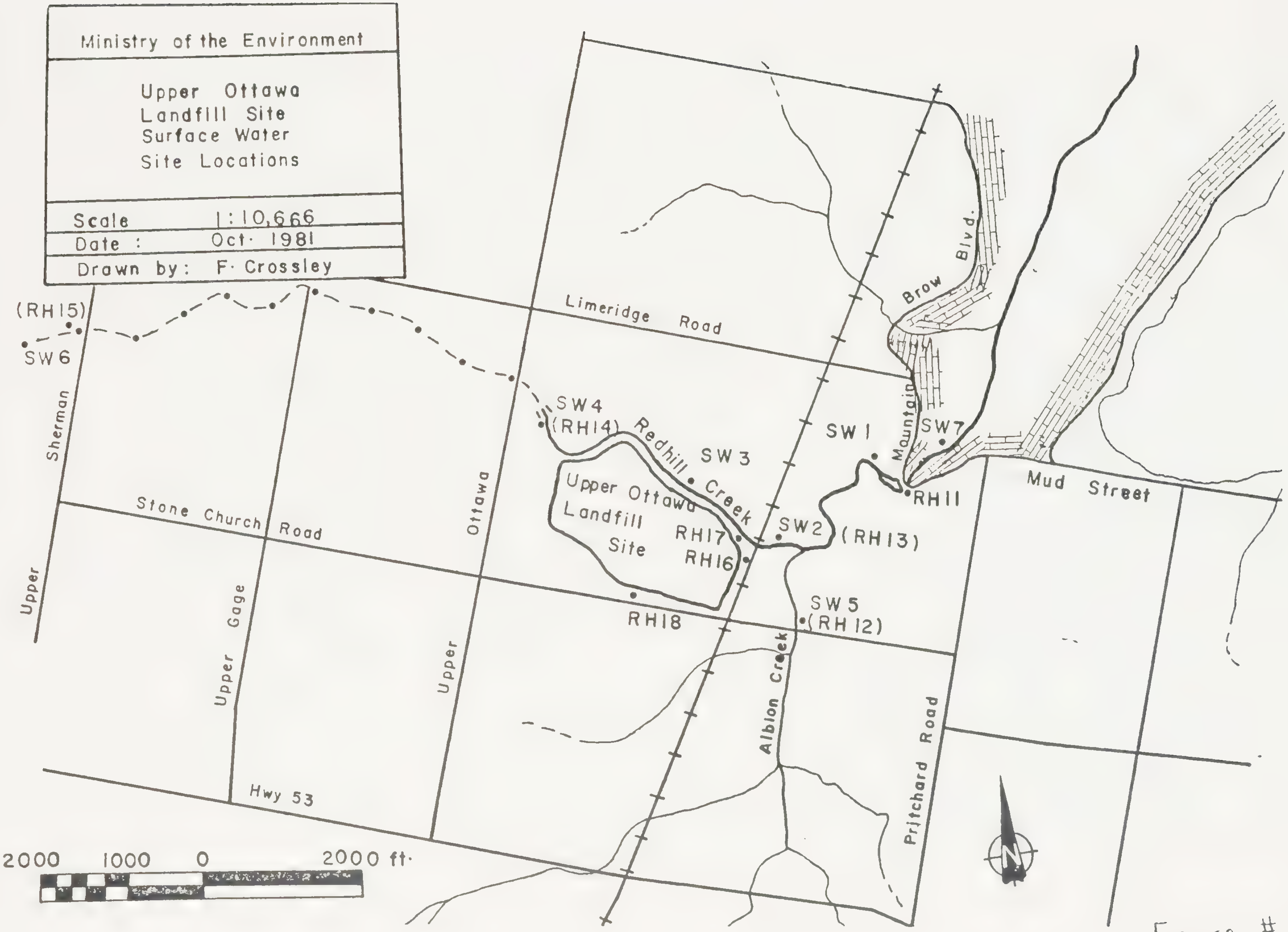

Ministry of the Environment
Upper Ottawa Landfill Site Surface Water Site Locations
Scale 1:10,666
Date : Oct. 1981
Drawn by: F. Crossley
(RH15)
SW6
Upper Sherman
Stone Church Road
Upper Gage
Hwy 53
Upper Ottawa
Limeridge Road
SW4 (RH14)
Redhill Creek
SW3
Upper Ottawa Landfill Site
RH17
RH16
RH18
SW2
(RH13)
SW1
Mountain Brow Blvd.
SW7
RH11
Mud Street
SW5 (RH12)
Albion Creek
Pritchard Road
N
2000 1000 0 2000 ft.

Figure # 2

HYDROGEOLOGICAL SETTING

GEOLOGY

The Upper Ottawa Landfill is situated on a gently undulating glacial till and a limestone plain above the Niagara Escarpment. The glacial till drift is thin, often less than 10 feet deep except in the moraine located just to the north of the landfill. The bedrock consists mainly of bedded dolomite of the Lockport Formation. This bedrock forms the caprock of the Escarpment and underlies the glacial soils. The rock surface slopes towards the east in the site area (ie. towards the escarpment) (GLA). The landfill site was located in an old quarry excavation. Therefore, the majority of the waste fill was placed directly on the bedrock. This is confirmed from test borings (Borelogs, GLA).

GROUNDWATER

According to GLA, the groundwater has mounded slightly beneath the waste causing a groundwater divide. Flows are occurring outwards from the waste in a northeast, east and southerly directions. The flow from the northeast is towards Redhill Creek. Therefore within the shallow flow system, the creek is receiving leachate as well as groundwater discharge or base flow. The creek forms a hydraulic boundary for the shallow flow system to the northeast (static level measurements from the standpipes, GLA).

Beneath the waste fill there is a downward movement of water into the bedrock. This indicates a recharge condition in the deep groundwater flow network. This deep flow system passes underneath Redhill Creek and heads north to north-east away from the landfill site. The Regional flow from the landfill site will trend towards the escarpment at Mount Albion Falls (piezometric levels GLA).

However, the specific flow paths could contrast to the above statement because of the fractured bedrock beneath the landfill site. The flow network could be very complex in such a rock formation. The complexity depends upon the fracture sizes, lengths, and connectivity.

For this report, the assumption that the groundwater flow trends towards the escarpment seems reasonably accurate. Possible leachate springs were observed by D. Jaggar of GLA in a visual inspection of the Mount Albion Falls area. A leachate spring was observed approx. 20 feet north-east of the falls, and 20 feet down the escarpment face. The other possible leachate spring is located just upstream of Redhill Creek Pond. The leachate springs are believed to be from the Upper Ottawa landfill site. Further sampling of the leachate would either verify or disprove this assumption. The presence of the leachate springs give additional evidence that the groundwater is moving towards the escarpment. Furthermore, the groundwater flow network will follow the topography of the Redhill Creek Valley which further verifies the movement of groundwater towards the escarpment.

SURFACE WATER

The landfill site is within the Redhill Creek watershed. The incipience of the creek is in the vicinity of Upper James and Stone Church Road. The creek has many small tributaries. Redhill Creek discharges into the Hamilton Bay. All along the creeks length, urbanization is occurring. The creek accepts urban runoff from storm sewers directly upstream (between Upper Sherman and Upper Ottawa Streets) of the landfill site. The creek throughout the above mentioned area is piped through an underground drain.

The actual drainage on the landfill site is divided because of the waste mound. Approximately 1/2 the runoff and seepage enters the creek from the north slopes while the other 1/2 of the runoff flows into the ditch along (south slope) Stone Church Road and then flows north east.

Water ponds in the northeast corner of the landfill site (Black Hole). A berm was placed in this low spot to prevent the ponded water from entering Redhill Creek. The water is pumped periodically by the Hamilton-Wentworth Region. On one inspection of the site, the berm was noticed to be leaking and leachate was entering the creek (early October/81). On a later inspection (November 13/81) the ponded area was dried up through excessive pumping. A permanent pump is going to be installed at the above mentioned location. The water is being pumped back up to a sanitary sewer on Stone Church Road where it is taken to the sewage treatment plant. Furthermore, French drains (November 13/81) are being installed at the toe of the southern slope. This collector system also leads to the sanitary sewer on Stone Church Road.

DISCUSSION

While compiling the data results, the author noticed discrepancies between the Ministry of the Environment's and Gartner Lee's results. The most noticeable differences between the two labs occurred in the parameter of chlorides and the parameter of conductivity. In all cases the Gartner Lee results were much lower for both the above mentioned parameters. This occurred in both the groundwater and surface water samples. The other parameters were in reasonable agreement between the two lab facilities except for the odd minor variance.

All the data presented in this report is Ministry of the Environment data (MOE) results from the Ministry's Laboratory in Toronto. The exception to this is the data tables (Table 2-1) of all background data for the Upper Ottawa Sanitary Landfill Site which includes Gartner Lee Associates' results (GLA).

There appears to be one spurious sample taken by the Ministry of the Environment. The sample in question is the one taken on May 1, 1980 for the groundwater data at borehole #7. All the parameters read exceedingly high for this sample. When this one sample is compared to the sample previously taken and the latest sample at this site, there is no relationship between the samples. The possible reason for this spurious sample result could be the high suspended solids level. This is not a natural occurrance in groundwater and can be used as evidence of a poor sample (unless this occurrence consistently repeats itself in which case, if sample procedures are proper, then the groundwater is highly contaminated). High suspended solids would affect the other parameters by increasing their readings.

There is some variation between the boreholes because of their site location. All the wells are finished into the bedrock. All the wells with the exception of borehole #11 are drilled into a shaly dolostone (Borehole logs - GLA). This variance skews the contour plumes because this type of formation contains poor quality water (ie) high conductivity, high chlorides, high total dissolved solids, etc.).

Boreholes 2, 3, and 4 are drilled through the actual waste (garbage up to 85 feet in depth - GLA). Therefore those above mentioned boreholes would be expected to have the poorest quality of water. The plume movement of contaminents should be away from those boreholes.

The surface water stations should show various trends depending upon where the contaminents are entering the creek.

The contribution of the landfill site to pollution leading to Redhill Creek can be determined by examining changes in chemical parameters in the creek adjacent to the site. The effects on groundwater can be delineated in a similar manner.

EFFECTS ON GROUNDWATER

Boreholes # 1 and #12 are hydraulically upgradient of the Upper Ottawa Street Landfill site. Therefore these boreholes can be used as a comparison to the remainder of the boreholes. These upgradient boreholes can be considered as background samples. Boreholes # 2 - # 4 penetrate the waste. These boreholes show elevated levels of chemical parameters that are related to landfill leachates. Boreholes #6-#11 are perimeter and downgradient wells. These wells can be used to show movement of the contaminants and the direction of the plume movement. This limits our knowledge of the extent and distribution of the landfill contaminents in the groundwater zone. High costs involved in developing boreholes limit the number of sampling points. However, the boreholes can still be used as good indicators to form a general overview of the landfill's effects on the groundwater.

REGULAR CHEMISTRY (Fig 3 to Fig 16)

Concentrations of chlorides appear to be mobile from the landfill site to the northeast, east and to the south. This is further substantiated by the levels of conductivity which show similar increases in the same areas. Both of these parameters are skewed to borehole # 11 because of the poorer quality water in the shale dolostone (Borehole logs - GLA).

The landfill seems to be affecting the parameters of alkalinity and chemical oxygen demand (COD). Alkalinity and COD are highest at the landfill boreholes. The perimeter wells to the northeast (BH#6) and to the east (BH#9) indicate high readings of both parameters in comparison with the background boreholes (BH#1, and BH#12).

Suspended solids can be used as an indicator of the reliability of a sample. Samples with unreasonably high levels of suspended solids are considered to be poor samples. Elevated levels of suspended solids can be due to poor well development, faulty sampling technique, or a low water level in the well which would cause a disturbance of the bottom sediments. Groundwater samples should be low in suspended

solids. If a sample containing high levels of suspended solids is actified for metal analysis, the acid will strip metal ions from the mineral lattice resulting in artificially high results. Borehole # 7 has the highest level of suspended solids. If this spurious sample (01/05/80) is eliminated, the levels reduce to background levels. The amount of suspended solids can have an effect on the other parameters. Therefore, this could possibly be the reason for the high readings on this day.

The wells on the landfill have high readings of total solids. Perimeter boreholes #6,7, and 8 also have high readings. Borehole #7 has been explained above. Total phosphorous and soluble phosphorous appear to correlate to total and dissolved solids. Total phosphorous is high at the landfill boreholes and at boreholes #6,7,and 8, which correlates with the readings of total soilds. This relationship could be caused by the phosphorous adsorbtion to the sediment particles.

Free ammonia is a common constituent of landfill leachate and therefore, is a good indicator of the presence of leachate. The migration of free ammonia will show actual paths of movement of the leachate in groundwater. A plume map (Fig. 15) was drawn to show the direction of movement. The map shows movement off site towards the north-east and east. This confirms the expected flow of the groundwater with the GLA results of the hydrogeological study of September, 1980.

Another plume map (Fig. 16) was drawn for total kjeldhal. This also further substantiated the movement of contaminants in the groundwater to the north-east and east.

The other regular chemistry parameters were high at the landfill with lower concentrations at the perimeter wells, showing the effects of assimilation and/or dilution.

HEAVY METALS (Fig 17 to Fig 26)

Total iron concentrations are highest at the landfill site. Borehole #6 also shows elevated concentrations of iron. This occurrence at borehole # 6 can be attributed to two possibilities. This particular borehole has a high suspended solids reading. The iron could be adsorbed on the sediment particles. A correlation of the two parameters (suspended solids and total iron) would verify or disprove this relationship. The other factor affecting borehole #6's reading is that it is located on the Wentworth till. This till is naturally high in iron content (the reason for its reddich colour). The probable reason for the high reading at this particular borehole (#6) probably is a combination of the above mentioned possibilities.

Aluminum is higher than the other heavy metal parameters. The background levels are relatively high. Aluminum does not appear to be mobile off the site. The high reading at borehole #7 could be because of the suspended solids. The aluminum could be adsorbed into the sediment particulate.

The other heavy metal parameters were high at the landfill with lower concentrations at the perimeter walls. There was no apparent effect by the landfill site on the following parameters: zinc, copper, nickel, lead, cadium, chromium, and arsenic. There is insufficient sampling data for manganese on the actual landfill site. However, since the perimeter wells show low level readings of manganese, this indicates that there are no signs of apparent movement of manganese off of the site.

PCB's (Fig 27)

Data on PCB's is limited in extent. There should be additional tests completed on the boreholes. From the data collected to date, there appears to be no apparent problem of PCB's in the groundwater.

ORGANIC SCAN

Two boreholes (#9 & #11) were tested for organics. Neither of the sites had any appreciable quantities of organics (See table 2-2, Organic Scan Table). Most chemical parameters were not detected. However, an organic scan should be carried out on all the boreholes.

PHENOL'S (Fig. 28)

Phenols are high at the landfill site with lower concentrations at the perimeter wells. This indicates that phenols are not moving off of the landfill site at this time.

GROUNDWATER: PARAMETER MEANS COMPARED TO PROVINCIAL DRINKING WATER CRITERIA (Table 2-2)

REGULAR CHEMISTRY

All stations exceeded the maximum limit for chlorides except for borehole #1. The other background well, borehole # 12 exceeded the maximum standard but in comparison with the other wells was relatively low. The perimeter wells all showed chloride contamination from the landfill site. Every station tested for dissolved solids and total kjeldhal, showed limits in excess of the set standards for both parameters. All stations were well below the maximum listed concentrations for nitrates.

HEAVY METALS

Total iron concentrations surpassed the maximum standards at all borehole stations. Only the stations located directly on the landfill site (BH# 2,3,4) exceeded the maximum levels for zinc. Borehole #12 one of the background wells, was the only well that did not exceed the maximum limit for copper. It appears that copper concentrations were naturally high in the area. All stations surpassed the standard for lead. The periphery stations had lower levels of lead in comparison to station #2 where the level was high. All stations exceeded the limit for cadium except borehole #12, however, the data indicates these levels were not very significant. So in actuality, these stations could be within the limit standards for cadmium. Chromium levels were high at the landfill boreholes and were either within or near the maximum levels at the periphery boreholes. Arsenic concentrations were generally low at all the sites tested but exceeded the maximum standards at the landfill wells. The boreholes sampled for manganese showed concentrations in excess of the limit. However, due to insufficient testing, this could be either a natural occurrence or the landfill is affecting levels of manganese or any combination of the above mentioned.

PCB'S

Insufficient data collected to date. There was no apparent problem as the data collected to date showed low levels of PCB's. However, with the presence of PCB's, the groundwater cannot be used as a drinking water supply because the zero tolerance level was exceeded.

ORGANIC SCAN

Neither of the two wells tested indicated an organic problem. At the present, there are no set Provincial limits for organics in drinking water.

PHENOLS

All the boreholes exceeded the set standards for phenols with the exception of borehole # 12.

OVERVIEW

The groundwater in the area samples is unsuitable as a potable water supply, as all boreholes exceeded many of the maximum levels for drinking water criteria. Therefore, the bedrock in the area east and north-east of the landfill should not be utilized as a private or municipal drinking water supply.

EFFECTS ON SURFACE WATER

Sample locations RH15(SW6) and RH14(SW4) are upstream controls and can be used as a comparison to the downstream locations. These upstream sample sites can be considered as background samples. Surface water sites RH16, RH17, and RH18 are leachate springs and runoff from the landfill. These sites show elevated levels of chemical parameters that are typical of landfill leachates. RH16 and RH18 are partially controlled. The runoff and seepage accumulates in a low spot (Black Hole) and is ponded by a man made berm. The water in the ponded area is pumped occasionally by the Hamilton-Wentworth Region to the sanitary sewer on Stone Church Road. This reduces the effects of RH16 and RH18 on Redhill Creek.

SW3 is located in Redhill Creek at approximately the midpoint of the landfill. This station can be used to show the effects of leachate entering Redhill Creek prior to the leachate spring (RH17). RH13(SW2) is the immediate downstream station from the landfill site. This station is used to measure the overall effects of the landfill site on Redhill Creek. The station on Albion Creek RH12 (SW5) can be used as a background sample. The downstream stations are RH13 (SW2), SW1, RH11 and SW7. These stations are used to show movement of contaminents and their concentrations downstream of the landfill site. The site locations can be used to form a general overview of the landfill's effect on surface water.

REGULAR CHEMISTRY (Fig. 29 to Fig.40)

Concentrations of chlorides, total solids, suspended solids and conductivity increase slightly immediately downstream (RH13) of the landfill site. For each of the above mentioned parameters, there was a decrease at station SW1 but an increase after Redhill Creek Pond (RH11). The possible reason for this increase could be the application of road salt on Mountain Brow and Mud Street. Evidence of this occurrence can be witnessed in the Redhill Creek graphs (chlorides, total solids, suspended solids and conductivity) as these parameters showed

an increase during the winter months (Jan. Feb. Mar. Apr.). The possible introduction of contaminated groundwater to Redhill Creek Pond could also cause this occurrence. At station SW7, these parameters fell to background levels.

The landfill site seems to have a slight affect on pH and alkalinity levels. However, the overall effect on Redhill Creek is insignificant because of nominal variation.

BOD and COD levels show a slight increase at SW3 from background levels. The concentrations show more elevated levels at the immediate downstream station, RH13 (SW2). These increases show the effects of organic degradation in the stream as materials enter the creek from leachate springs and from seepage all along the northern face of the landfill site. Downstream at station SW1, the levels show a decrease, but increase again at RH11. The possible reason for this effect could be the algae growth in Redhill Creek Pond. BOD and COD levels decrease to background levels at SW7.

Free ammonia and total kjeldhal levels increase at SW3 and become even more elevated at RH13 (SW2). These increases show the effects of materials entering Redhill Creek from the leachate springs (RH17) and from seepage along the northern side of the landfill site. SW1 has concentrations at background levels. After Redhill Creek Pond there is a sharp increase in both parameters. The possible reason for this happening could be the addition of groundwater contamination to the creek (groundwater plume maps of free ammonia and total kjeldhal, Fig. 15 and 16). SW 1, the downstream station, returned to background levels for both chemical parameters.

Nitrite and nitrate showed a slight increase at SW3 and a greater increase at RH13(SW2). The elevated concentrations are a direct result of the addition of ammonia from the landfill site. A portion of the ammonia is oxidized, which increases nitrites and nitrates. The concentrations of these parameters decrease downstream from RH13(SW2) to background levels at SW7.

The landfill site has no demonstrated effect on phosphorous levels in Redhill Creek. The leachate samples are relatively low in phosphorous and the creek only displays minimal fluctuations of phosphorous concentrations throughout the sampled area.

HEAVY METALS (Fig. 41 to Fig. 50)

Total iron and zinc show an increase at the immediate upstream site (RH14 (SW4)) from the landfill. Total iron and zinc concentrations decrease downstream from RH14 (SW4). The leachate spring (RH17) has a low concentration of total iron and zinc. Therefore, the landfill is not the major contributor of total iron or zinc to Redhill Creek. Concentrations fell back to background levels for both parameters by RH11.

The following group of heavy metals did not display a significant increase downstream of the landfill site; copper, nickel, lead, cadmium, chromium, arsenic and manganese. The heavy metals mentioned above showed minimal fluctuations of concentration values throughout the sampled area of the watershed. These parameters also had low levels at the leachate spring (RH17) showing that these heavy metals were not escaping the landfill site in appreciable quantities.

Aluminum shows an increase at SW3 in comparison to the upstream controls. The levels decrease downstream from SW3. The leachate spring (RH17) has a relatively low concentration of aluminum

PCB's

There is no indication of a PCB problem from the landfill site. Evidence of this can be seen, as the upstream control (RH14) and the downstream station (RH11) show that the PCB level's in the creek are below the lab's detection limits.

ORGANIC SCAN

Surface water sites RH14 (SW4) and SW1 were sampled for organics. The upstream and downstream site showed virtually no trace organics in the creek. Organics do not appear to be a problem in the sampled portion of Redhill Creek.

PHENOLS (Fig. 51)

Phenols showed no significant increase with minimal variations. The leachate spring (RH17) had a low concentration of phenols. This shows that the landfill site is not contaminating the creek with phenols.

BACTERIA (Fig. 52 to Fig. 56)

All the bacteria counts showed elevated values at RH14(SW4). Total coliforms, fecal coliforms and fecal streptocci showed decreases in values downstream of RH14(SW4). Only background colonies showed an increase of values at the downstream site (RH13 SW2). The major loading of bacterial pollution is entering the creek between Upper Sherman and Upper Ottawa Streets in the residential area above the landfill site (Redhill Creek accepts runoff from storm sewers in this urbanized area). The residential area is probably responsible for the bacterial contamination due to leakage from sanitary sewers to storm sewers. Evidence of this occurrence can be seen by the fecal coliform: fecal streptococci ratio which has an elevated level at RH14 (SW4). The high ratio indicates that the bacteria is of recent human origin in this area. Downstream of RH14 (SW4), the ration decreases indicating a mixture of human and animal bacterial pollution.

SURFACE WATER: PARAMETER MEANS COMPARED TO PROVINCIAL DRINKING WATER CRITERIA (Table 2-3)

Regular Chemistry

All stations met the requirements for chlorides except for stations RH16 and RH18. The maximum limits for dissolved solids and total kjeldhal Nitrogen were exceeded at every station. All stations were within the standards set for nitrates.

Heavy Metals

Total iron exceeded the maximum limit at every station except RH17. This shows that the leachate spring has low quantities of total iron. Therefore the landfill site is not the major factor in the input of total iron to the stream. Levels of zinc, copper, and arsenic were below the maximum levels set for each parameter. All stations met the requirements for lead except station RH18. Cadmium levels were below the maximum limit except for RH16. Chromium concentrations did not exceed standards for this parameter except at RH16 and RH18. Only stations RH17 and RH18 were below the maximum level for manganese.

PCB's

The samples indicate that there was no apparent problem with PCB's from the landfill site. All the stations tested for PCB's were either less than the detection limit (indicating trace amounts of the substance) or were not detected in the water. However, with the presence of PCB's, the water cannot be used as a potable water supply because it exceeds the zero tolerance level.

ORGANIC SCAN

Neither site (upstream of the landfill site and downstream of the site) tested for organics showed any indication of an organic problem in the creek. Most organics tested were not detectable. At the present, there are no set Provincial limits for organics in drinking water.

Phenols

All the stations were below or near the set maximum limit for phenols. Only stations RH16 and RH18 greatly exceeded these limits.

Bacteria

Total coliforms and fecal coliforms greatly exceeded the maximum limits for drinking water. Every station showed greatly elevated levels compared to the criteria.

Overview

The surface water in the area sampled is unsuitable as a potable water supply as many parameters exceeded the Ministry's drinking water criteria. The extremely high bacteria counts are a potential health hazard to humans. When surface water sources are used as drinking water supplies they should be treated prior to consumption.

SURFACE WATER: PARAMETER MEANS COMPARED TO PROVINCIAL WATER QUALITY OBJECTIVES (Table 2-4)

Regular Chemistry

pH values fell within the set range values. The percentage of un-ionized ammonia in aqueous ammonia solution for different temperature and pH conditions can be calculated (Table 2-4 for calculation of un-ionized ammonia). Un-ionized ammonia met maximum limits at the background sites only (RH14 (SW4), RH12 (SW5), and RH15(SW6)). The downstream sites show contamination by un-ionized ammonia which indicates the landfill is affecting the creek and will exhibit toxicity to fish populations.

Heavy Metals

Total iron and cadmium exceeded the maximum objectives at every station except the leachate spring RH17. Zinc levels exceed the maximum objectives at every station but stations RH 15 (SW6) and RH12 (SW5). These stations were background controls. However, station RH14 (SW4) showed the largest increase in zinc in the creek. This displays an extraneous affect influencing zinc levels. All stations showed limits above the maximum guideline for copper. Only RH16 and RH18 exceeded the maximum standards for nickel. Concentrations of lead were near or below the maximum objective except for RH16 and RH18. Aluminum exceeded the maximum guideline at all sites except RH14 (SW14) and SW7. All stations were below the maximum guidelines for arsenic.

PCB's

The data was collected for an upstream control, a downstream site, and for Redhill Creek at Mount Albion Falls. From the samples taken, there was no indication of a PCB problem from the landfill. Trace amounts of PCB's were found in Redhill Creek. The presence of PCB's exceeds the zero tolerance level set as a Provincial water quality objective.

Organic Scan

The two sites (one upstream and one downstream of the landfill) showed no indication of an organic problem. In most cases the organics tested were not detectable. The organics tested with set maximum objectives and/or guidelines, showed that the organics at both stations were below the Federal water quality objectives.

Phenols

Only stations RH16 and RH18 greatly exceeded the water quality guidelines for phenols.

Bacteria

All stations showed elevated levels of total coliforms and fecal coliforms. This indicates that there is a potential for health hazards with respect to body contact recreation (ie. a potential health hazard if the fecal coliform geometric mean exceeds 100 per 100 ml and water quality is considered impaired if the total coliform geometric mean exceeds 1000 per 100 ml).

Overview

The surface water in the sampled area is unsuitable as a contact recreational resource because of the potential health hazard due to bacterial pollution. The water has a potential to be detrimental to aquatic life because of the un-ionized ammonia and the heavy metals that exceed the maximum concentrations.

REDHILL CREEK AT MOUNT ALBION FALLS (RH11)

Table 2-5 was compiled to see the trends during March to June from 1978 to 1981. This period, March to June, is the period that maximum rainfall and infiltration occurs and the effects of evapotranspiration are reduced. The infiltration fraction of the precipitation is the principle contributor to leachate generation from the sanitary landfill, excluding liquid wastes dumped at the site (MOE 1978). Maximum infiltration occurs during spring thaw (Rover and Farquhar and MOE 1978) concurring with peak streamflow. Therefore, maximum leachate generation and overland runoff would occur between March and June.

A comparison of 1978's means for March to June through 1981's means for March to June were tabulated (Table 2-5) to see if the trends were increasing or decreasing over time. Chlorides, total solids, suspended solids, and conductivity levels showed a general increase at RH11. Two possible reasons for this occurrence could be the contamination of the creek from groundwater discharge to the creek or the increase in the use of road salts in the area or any combination of the two possibilites.

BOD, COD, total kjeldhal, and free ammonia levels have showed a general decline. Nitrite has remained similar while nitrates have shown a slight increase. In general, the products of organic breakdown have shown a decrease in time. This is probably due to the closure of the landfill and the final cover over the domestic refuse. Heavy metals have remained at similar levels throughout the study period except total iron which has shown a decrease. Zinc has shown an increase but the event appears to be due to extraneous circumstances (further concentrated sampling may detect the source of this event). Phosphorous levels have remained similar throughout the sample period. Bacterial pollution at RH11 has shown a general increase. However, it has already been shown that the landfill site is not the major contributor of bacterial pollution to the creek.

Table 2-6 and graphs G1 - G15 were compiled to show the trends since final closure date, October 1980, of the sanitary landfill site. Also the graphs can be used as a visual aid to show any possible seasonal trends of Redhill Creek at Mount Albion Falls. Table 2-7 is a summary of all data collected for Redhill Creek at Mount Albion Falls (RH11) to the present date of the report.

Trends from closure date to June 1981, were similar to the comparison of data means from March to June of 1978 through 1981. The most noticable trend is the reduction of the nitrogens especially filtered ammonia. The possible reason for this event could be the final covering of the domestic refuse. This would reduce the amount of nitrogen entering the creek via overland runoff.

Graphs G1 to G15 showed no discernible seasonal trends in Redhill Creek at Mount Ablion Falls (RH11) except for the previously mentioned trend of chlorides in the winter. The lack of seasonal trends is probably due to the relationship of the stream flow and leachate generation to rainfall, and the seasonal effects of evapotranspiration on infiltration (MOE 1978).

CONCLUSIONS

Groundwater Aspects

1. The contaminated groundwater plume shows movement to the east and north-east towards Mount Albion Falls at the Escarpment. Evidence of this occurrence is shown by the chemical parameters of free ammonia, total kjeldhal nitrogen, chlorides, and COD.

2. All regular chemistry parameters show high concentrations of levels at the boreholes located in the actual landfill, with the perimeter boreholes showing lower concentrations because of assimilation and/or dilution.

3. Heavy metals are not moving off site in the groundwater from the landfill site in appreciable quantities.

4. PCB's, phenols, and trace organics, although limited extent in analysis, indicate no apparent problem at the present time.

5. The groundwater is unsuitable for human consumption as many parameters exceed the maximum limits set by the Provincial Drinking Water Criteria. The groundwater in the sampled area and north-east and east of the landfill site should not be used as a potable water supply.

Surface Water Aspects

1. All regular chemistry parameters except phosphorous showed elevated levels immediately downstream of the landfill site. These overall effects were negligible on Redhill Creek as the concentration levels decreased to background levels by the final sampling station. This shows the effect of assimilation and/or dilution.

2. The landfill is contributing pollutants to the creek. This is causing the degradation of the creek in the localized area of the landfill site. The most serious pollutants are free ammonia, BOD, COD, and total kjeldhal nitrogen.

3. The additon of free ammonia to the creek also causes an increase in nitrites and nitrates through oxidation of the ammonia. Free ammonia in the un-ionized form can be toxic to aquatic life.

4. Heavy metals are not a problem as nominal quantities are leaving the landfill site. However, in the sampled area of the creek, heavy metals slightly exceed the Ministry's objectives. This phenomena appears to be due to an occurrence upstream of the landfill except for alumium which increases at the landfill site.

5. PCB's, phenols, and trace organics, although limited in extent of analysis, indicate no apparent problem at the present time.

6. Bacterial pollution is entering Redhill Creek from the residential sector upstream of the landfill site.

7. Redhill Creek, in the sampled area, cannot be used as a potable water supply as many parameters, (especially bacteria) exceed the Provincial Drinking Water Criteria.

8. Redhill Creek, in the sampled area, is unsuitable as a contact recreational resource because of the potential health hazard due to bacterial pollution.

9. Redhill Creek at Mount Albion Falls (RH11) has shown a reduction in products of organic breakdown (nitrogens, BOD, and COD) probably due to the closure of the landfill site and the final clay covering of the refuse.

10. No discernible seasonal trends were apparent at Mount Albion Falls (Redhill Creek) due to the landfill site at this time.

11. The installation of french drains, the pump house, and toe collector systems that lead to the sanitary sewer on Stone Church Road should show an improvement in Redhill Creek. These systems will reduce the amount of leachate entering the creek. Erosional controls will also reduce the effects of streambank and toe erosion by the creek. The application of grass (hydroseeding) will reduce the amount of infiltration through evapotranspiration and reduce the overland runoff entering the creek. These developments that are presently underway should aid in the rehabilitation of Redhill Creek.

REFERENCES

1. Craig, Harold Douglas - Personal Communications Ministry of the Environment, 1981

2. Gartner Lee and Associates - Hydrogeological Study, Leachate and Gas Impacts (Stagee II), Upper Ottawa Street Landfill, for Regional Municipality of Hamilton-Wentworth, 1980

3. H.R.C.A - Redhill Creek Watershed Management Study, A Report to the Hamilton Region Conservation Authority by M.M. Dillon Limited Consulting Engineers and Planners.

4. Ministry of the Environment; Technical Support Section (West Central Region), The effects of the Upper Ottawa Street Landfill on Redhill Creek, 1978.

5. Ministry of the Environment Files - Compilation of Material Pertaining to the Upper Ottawa Sanitary Landfill Site (continuous)

6. Ministry of the Environment - Water Management, 1978.

APPENDIX I

Ministry of the Environment

Upper Ottawa
Landfill Site
Boreholes
3

Scale 1 : 8333.3
Date: Oct. 1981
Drawn by: F. Crossley

CHLORIDES

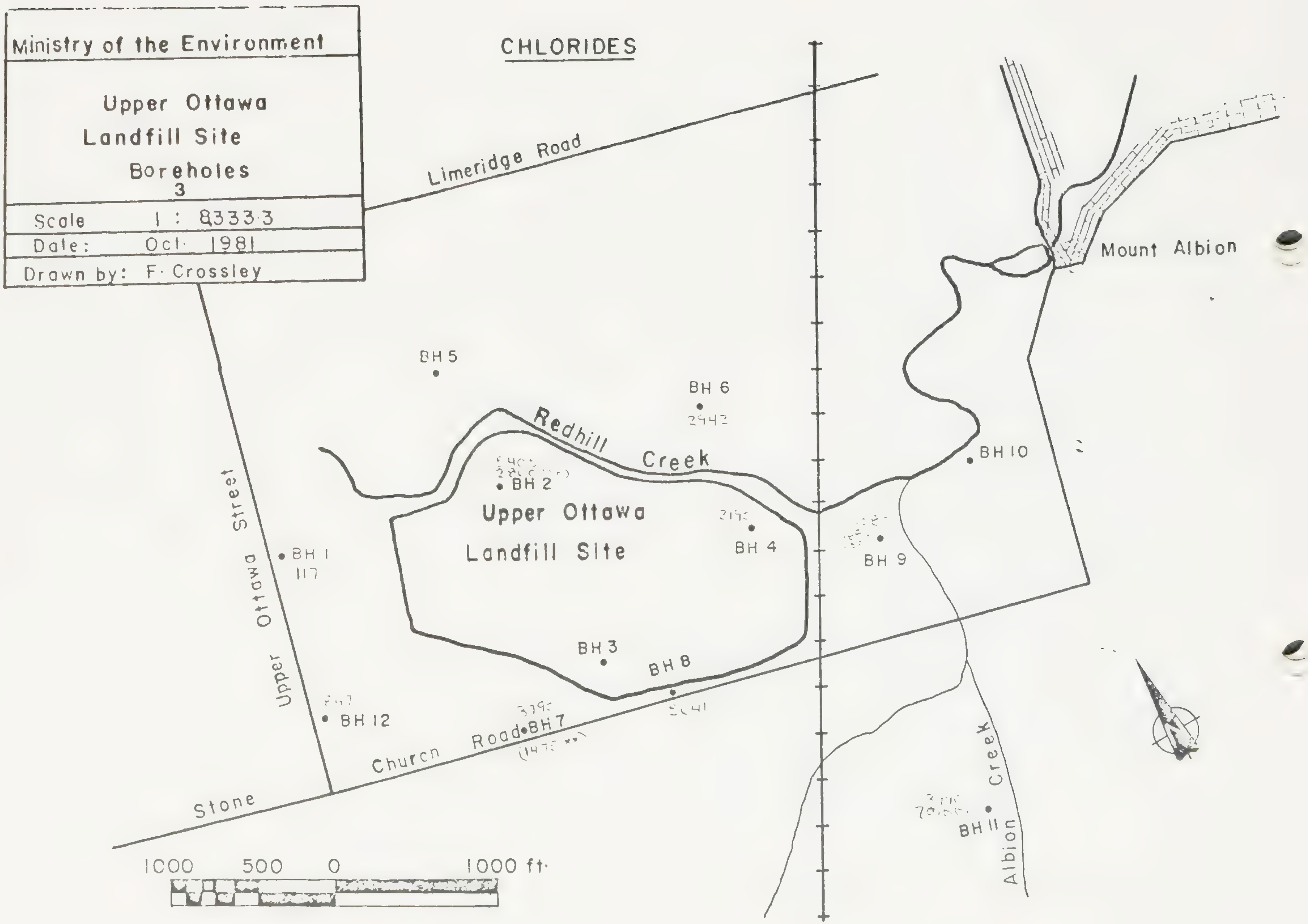
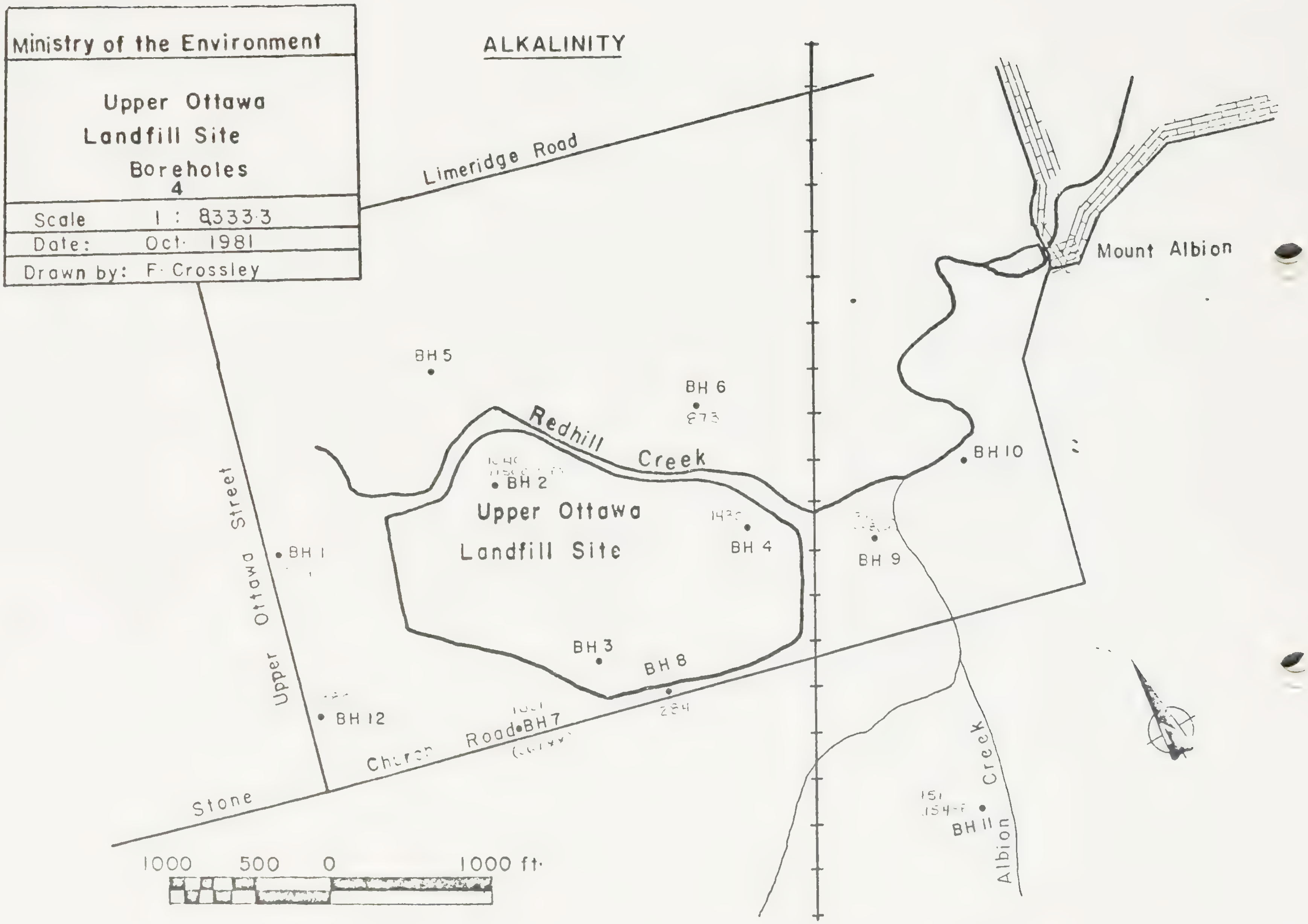
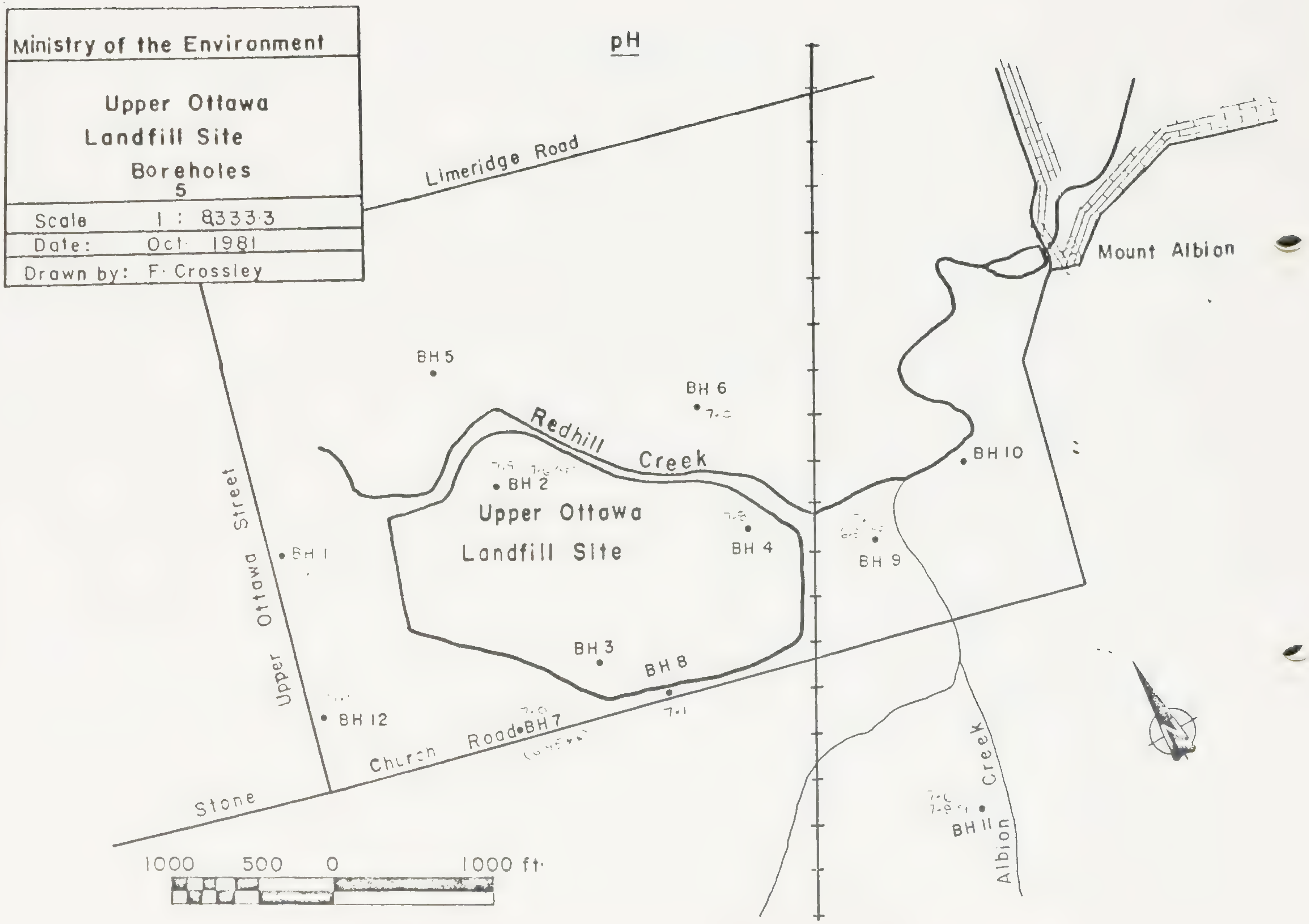


Figure # 3




Ministry of the Environment

Upper Ottawa
Landfill Site
Boreholes
5

Scale 1 : 8333.3
Date: Oct. 1981
Drawn by: F. Crossley

Figure #[illegible]

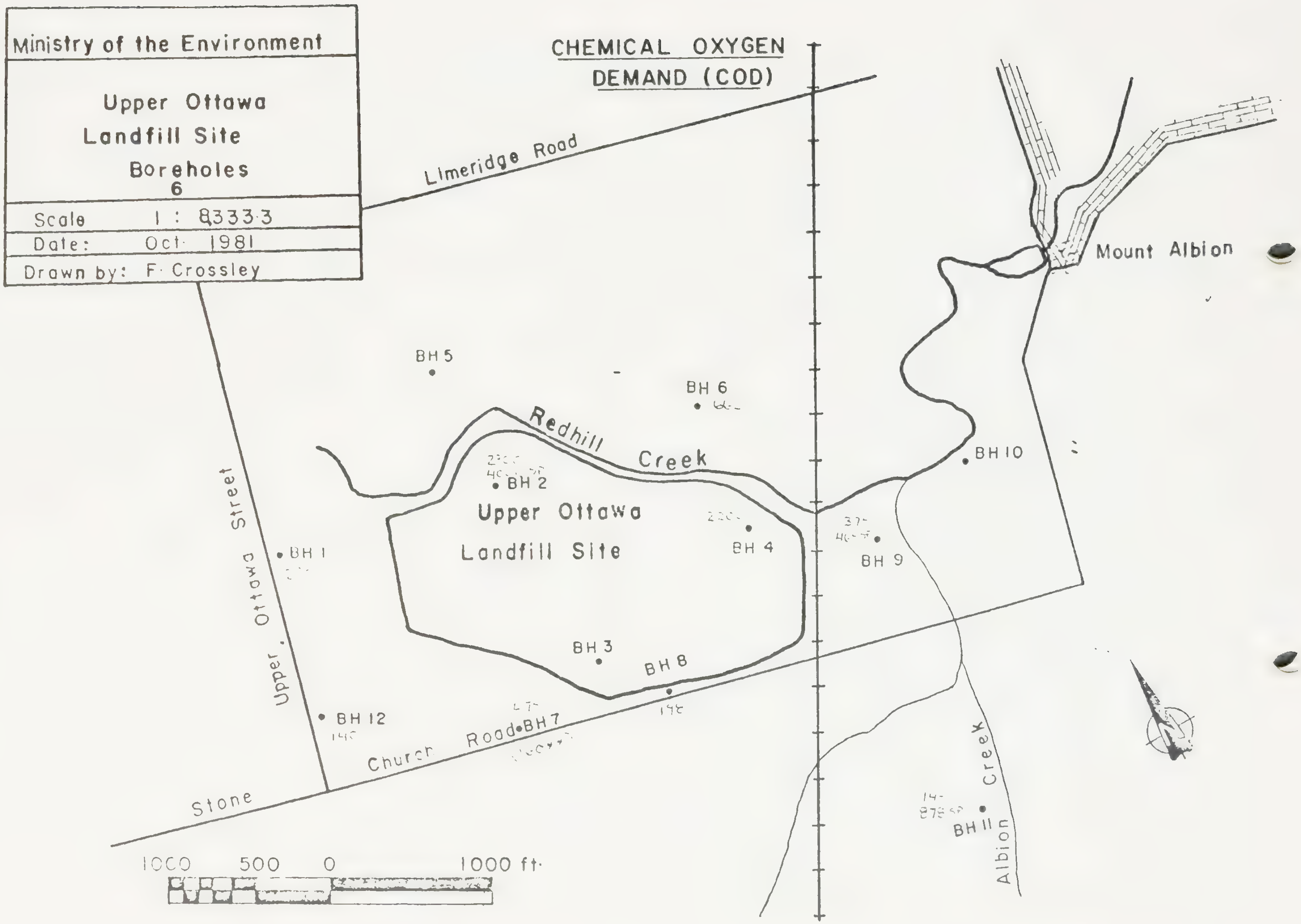
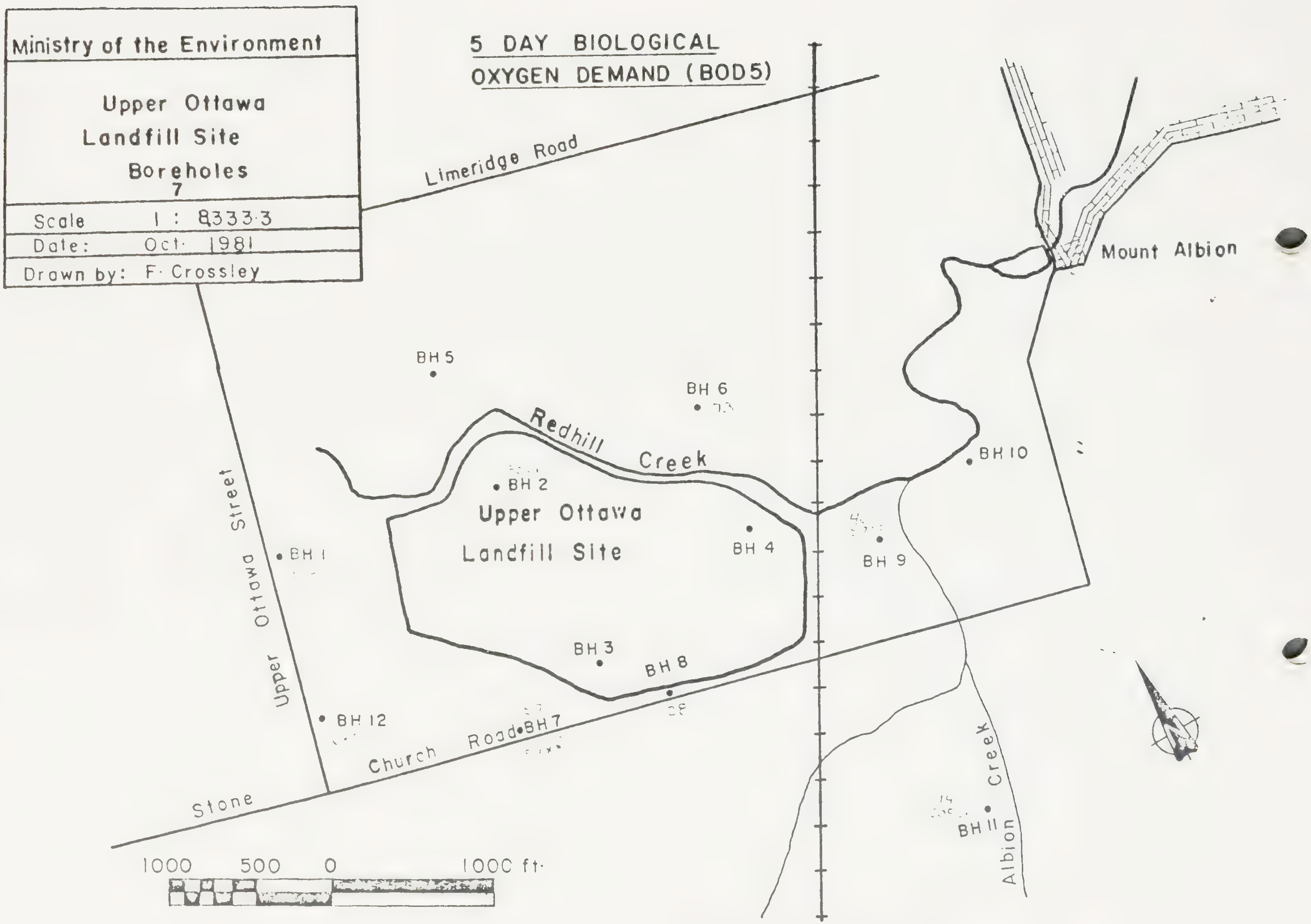

CHEMICAL OXYGEN DEMAND (COD)
Ministry of the Environment
Upper Ottawa Landfill Site Boreholes 6
Scale 1 : 8333.3
Date: Oct. 1981
Drawn by: F. Crossley
Limeridge Road
Upper Ottawa Street
Stone Church Road
Redhill Creek
Albion Creek
Mount Albion
Upper Ottawa Landfill Site
BH 1
BH 2
BH 3
BH 4
BH 5
BH 6
BH 7
BH 8
BH 9
BH 10
BH 11
BH 12
1000
500
0
1000 ft.

Figure 11.6



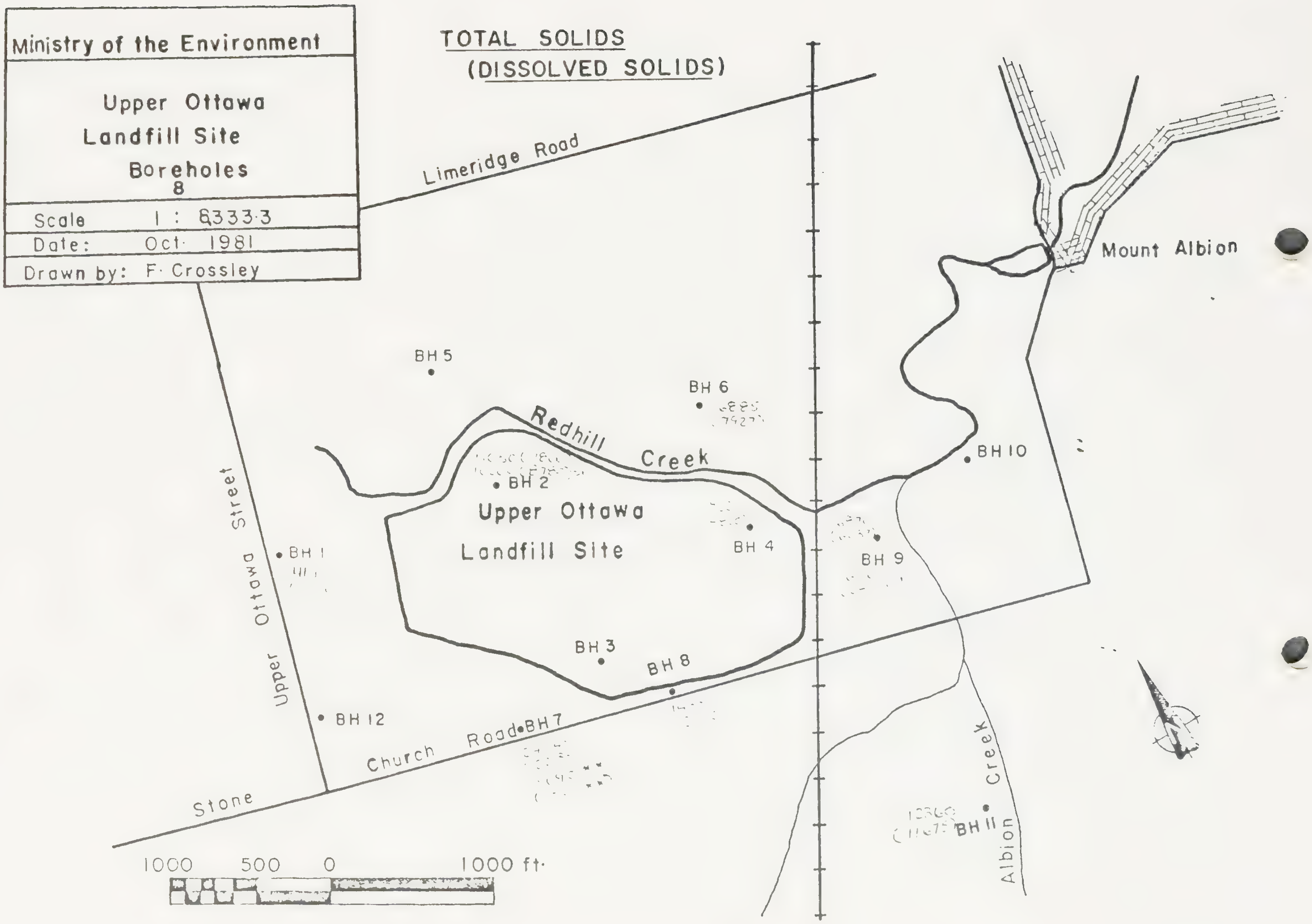
Ministry of the Environment

Upper Ottawa
Landfill Site
Boreholes
7

Scale 1 : 8333.3
Date: Oct. 1981
Drawn by: F. Crossley

Figure #7

TOTAL SOLIDS
(DISSOLVED SOLIDS)



Ministry of the Environment

Upper Ottawa
Landfill Site
Boreholes
8

Scale 1 : 6333.3
Date: Oct. 1981
Drawn by: F. Crossley

Figure #8

CONDUCTIVITY

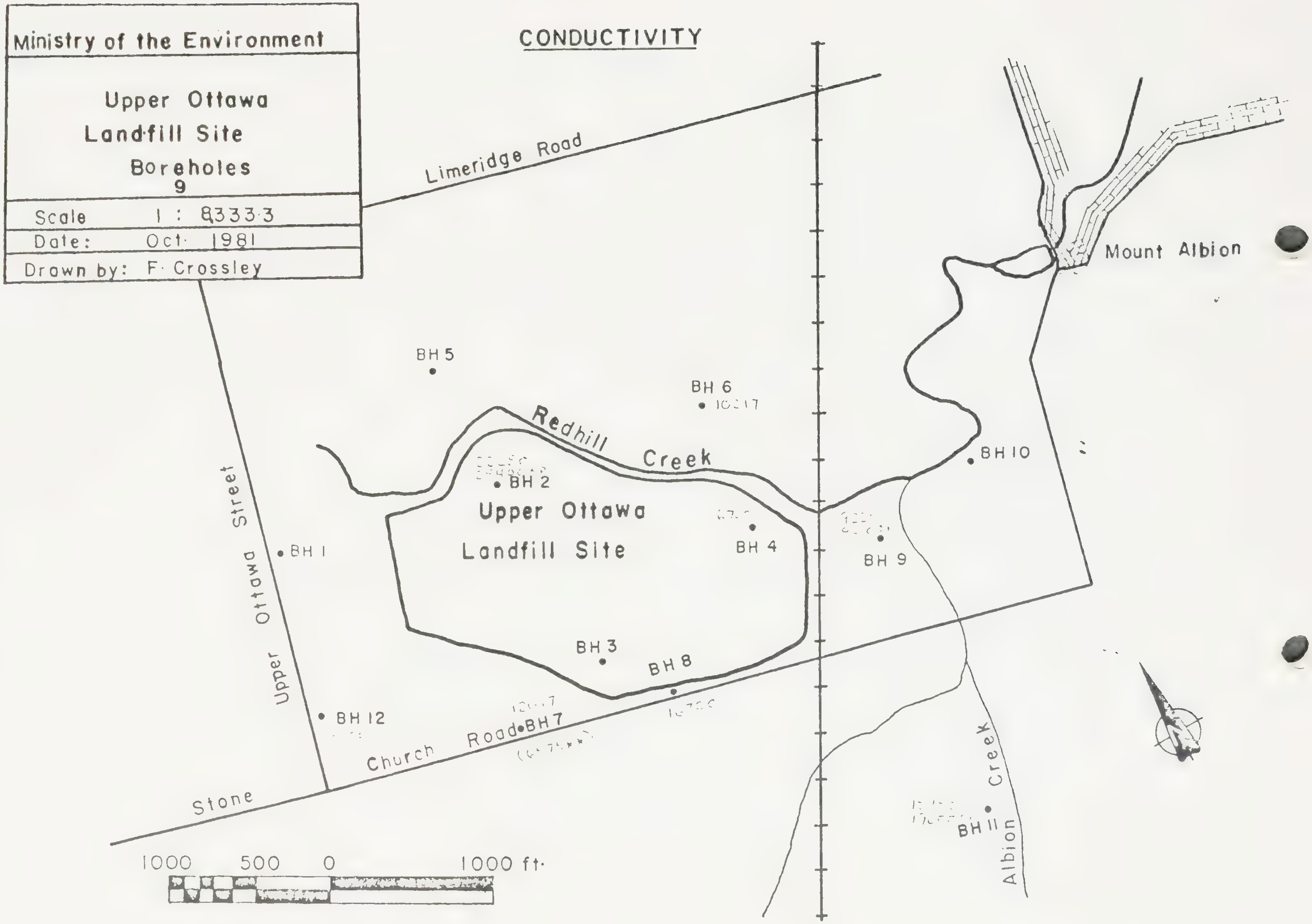


Figure #9

FREE AMMONIA

Ministry of the Environment

Upper Ottawa
Landfill Site
Boreholes
10

Scale 1 : 8333.3
Date: Oct. 1981
Drawn by: F. Crossley

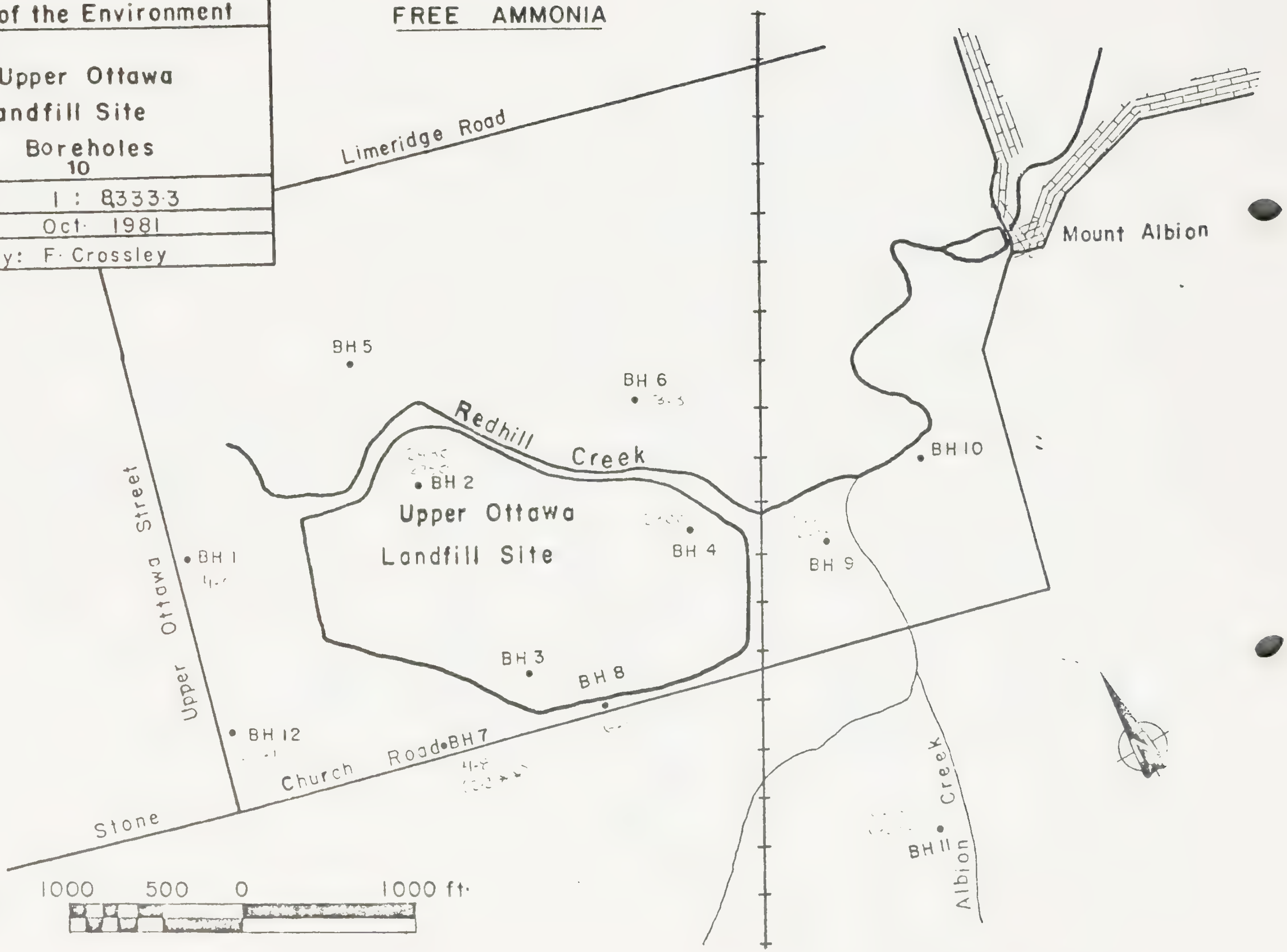


Figure # 1C

TOTAL KJELDHAL

Ministry of the Environment

Upper Ottawa
Landfill Site
Boreholes
11

Scale 1 : 8333.3
Date: Oct. 1981
Drawn by: F. Crossley

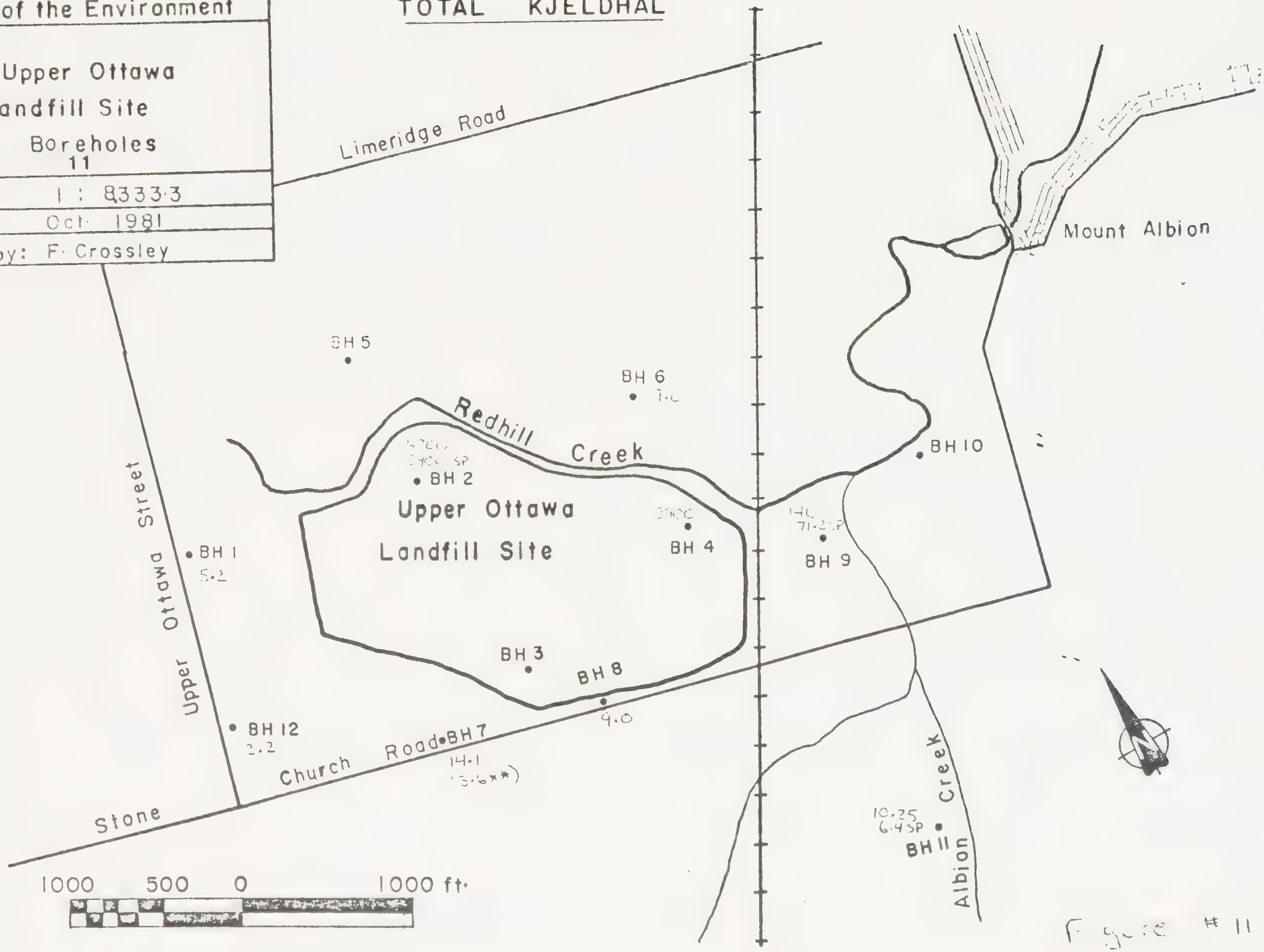
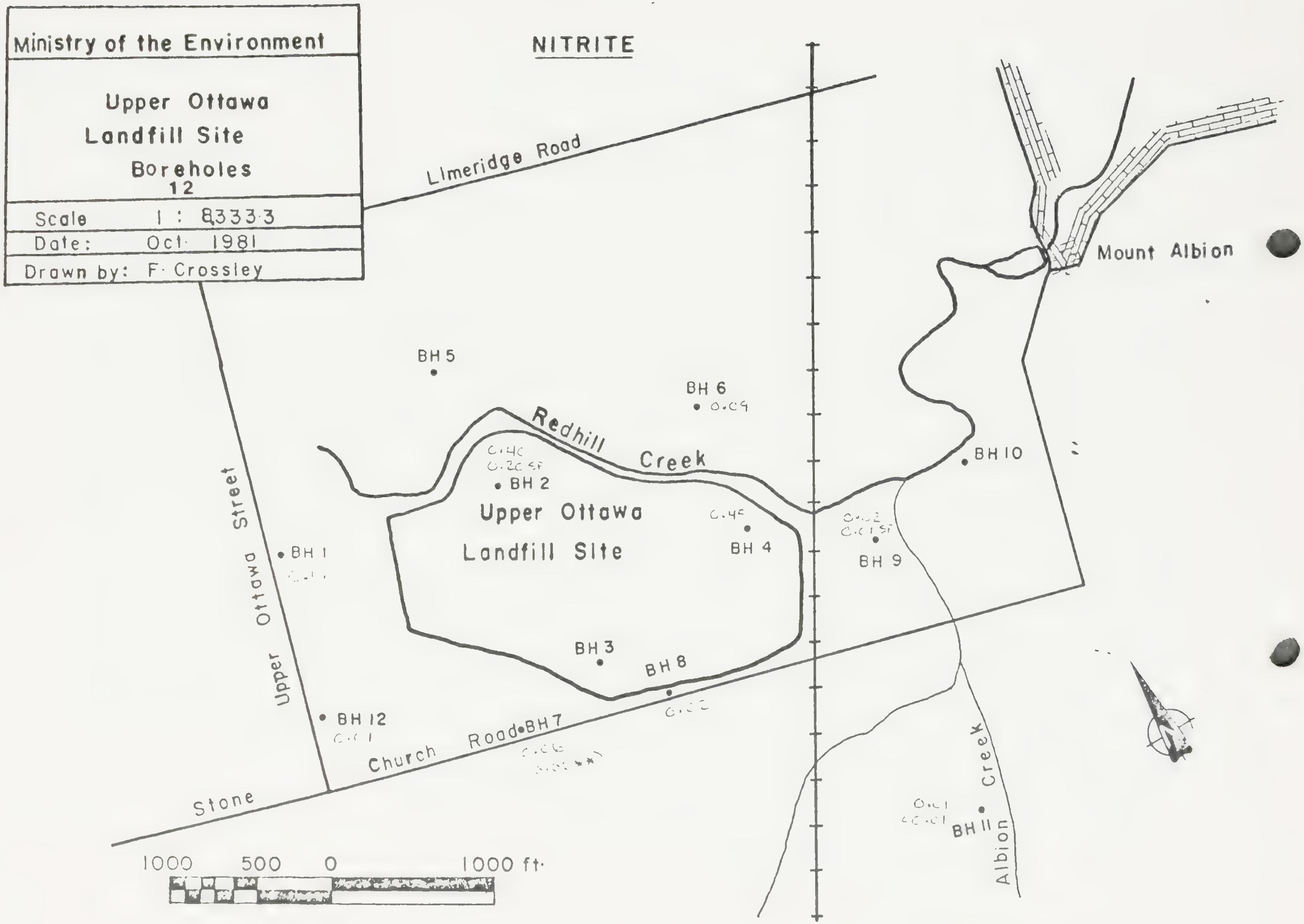


Figure #11

NITRITE



Ministry of the Environment

Upper Ottawa
Landfill Site
Boreholes
12

Scale 1 : 8333.3
Date: Oct. 1981
Drawn by: F. Crossley

Figure #1d

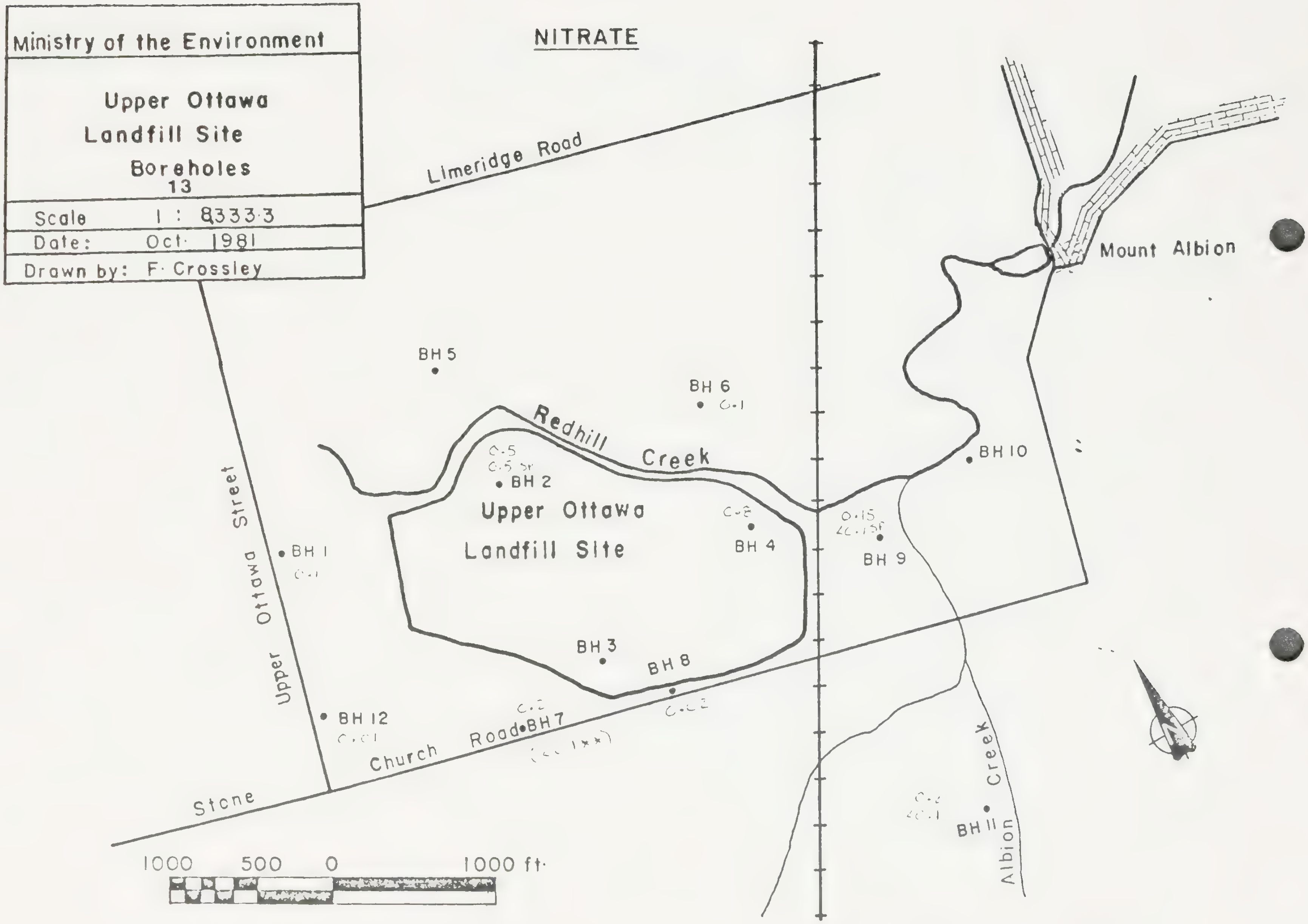

NITRATE
Ministry of the Environment
Upper Ottawa
Landfill Site
Boreholes
13
Scale 1 : 8333.3
Date: Oct. 1981
Drawn by: F. Crossley
Limeridge Road
Upper Ottawa Street
Stone Church Road
Redhill Creek
Albion Creek
Mount Albion
Upper Ottawa Landfill Site
BH 1
0.1
BH 2
0.5
0.5 sr
BH 3
BH 4
0.8
BH 5
BH 6
0.1
BH 7
0.2
(<0.1**)
BH 8
0.02
BH 9
0.15
<0.15f
BH 10
BH 11
0.2
<0.1
BH 12
0.01
1000
500
0
1000 ft.

Figure N13

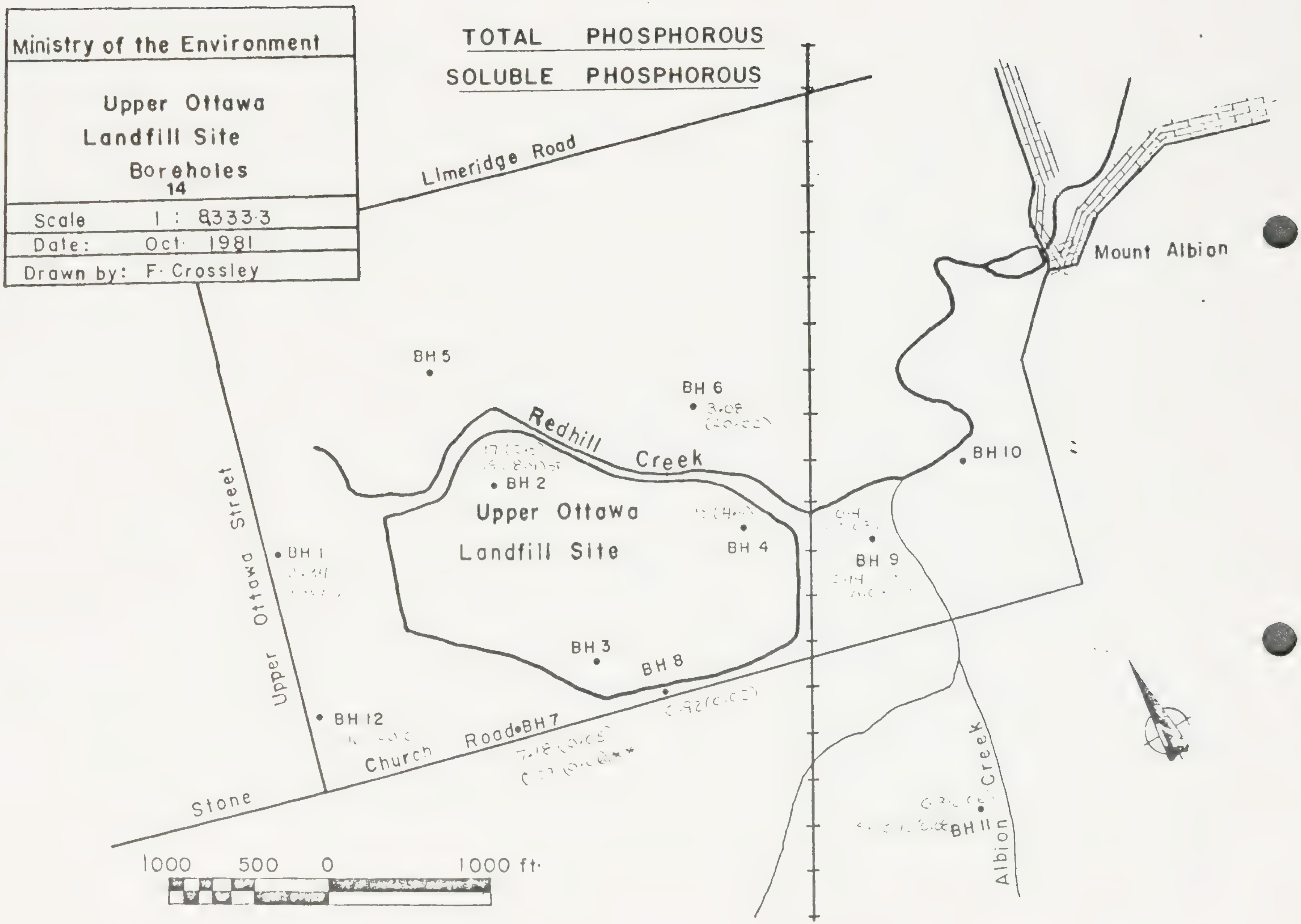
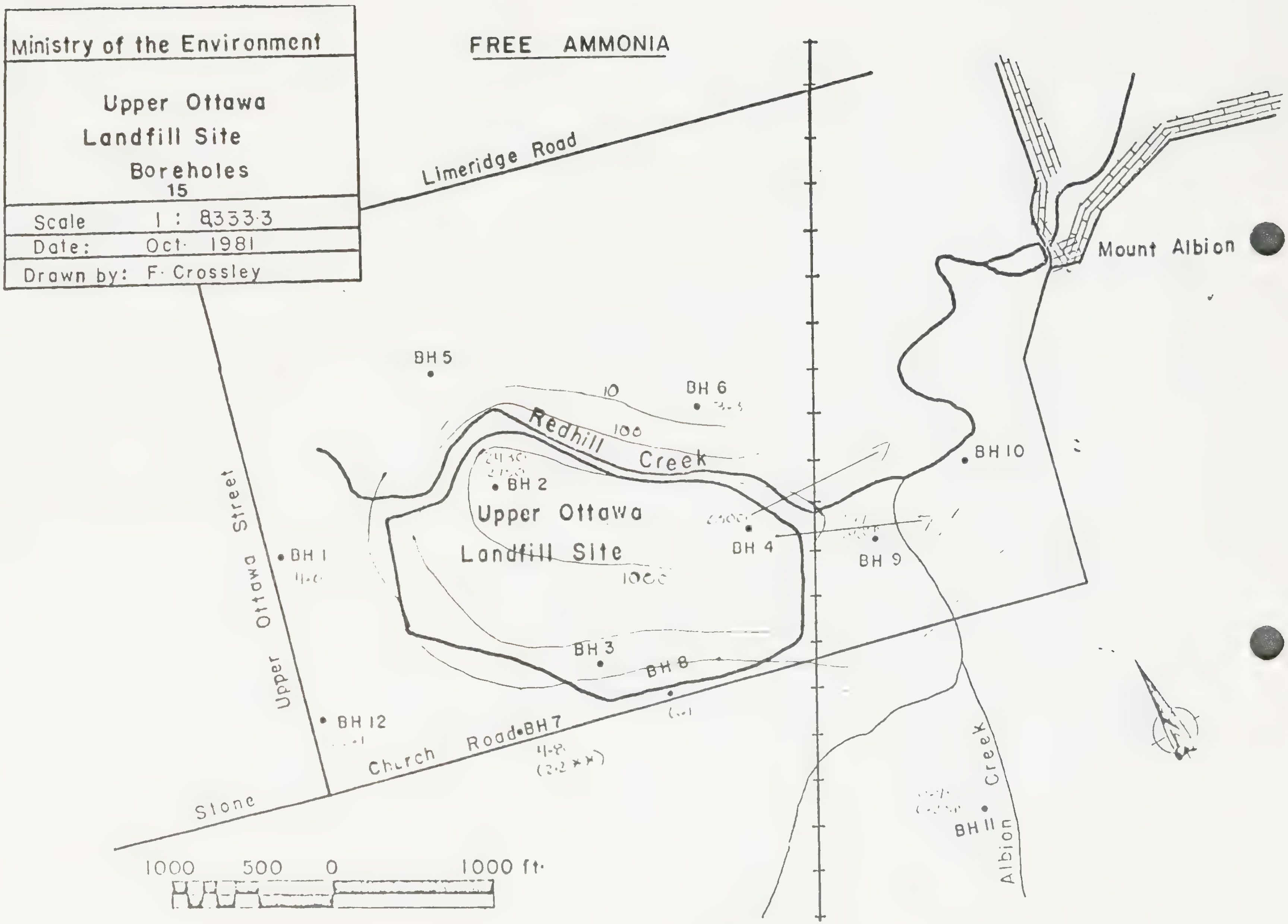

TOTAL PHOSPHOROUS
SOLUBLE PHOSPHOROUS
Ministry of the Environment
Upper Ottawa
Landfill Site
Boreholes
14
Scale 1 : 8333.3
Date: Oct. 1981
Drawn by: F. Crossley
Limeridge Road
Mount Albion
Redhill Creek
Upper Ottawa
Landfill Site
BH 1
BH 2
BH 3
BH 4
BH 5
BH 6
3.08
BH 7
7.18 (0.05)
BH 8
0.92(0.03)
BH 9
BH 10
BH 11
BH 12
Upper Ottawa Street
Stone Church Road
Albion Creek
1000
500
0
1000 ft.

Figure #14

FREE AMMONIA



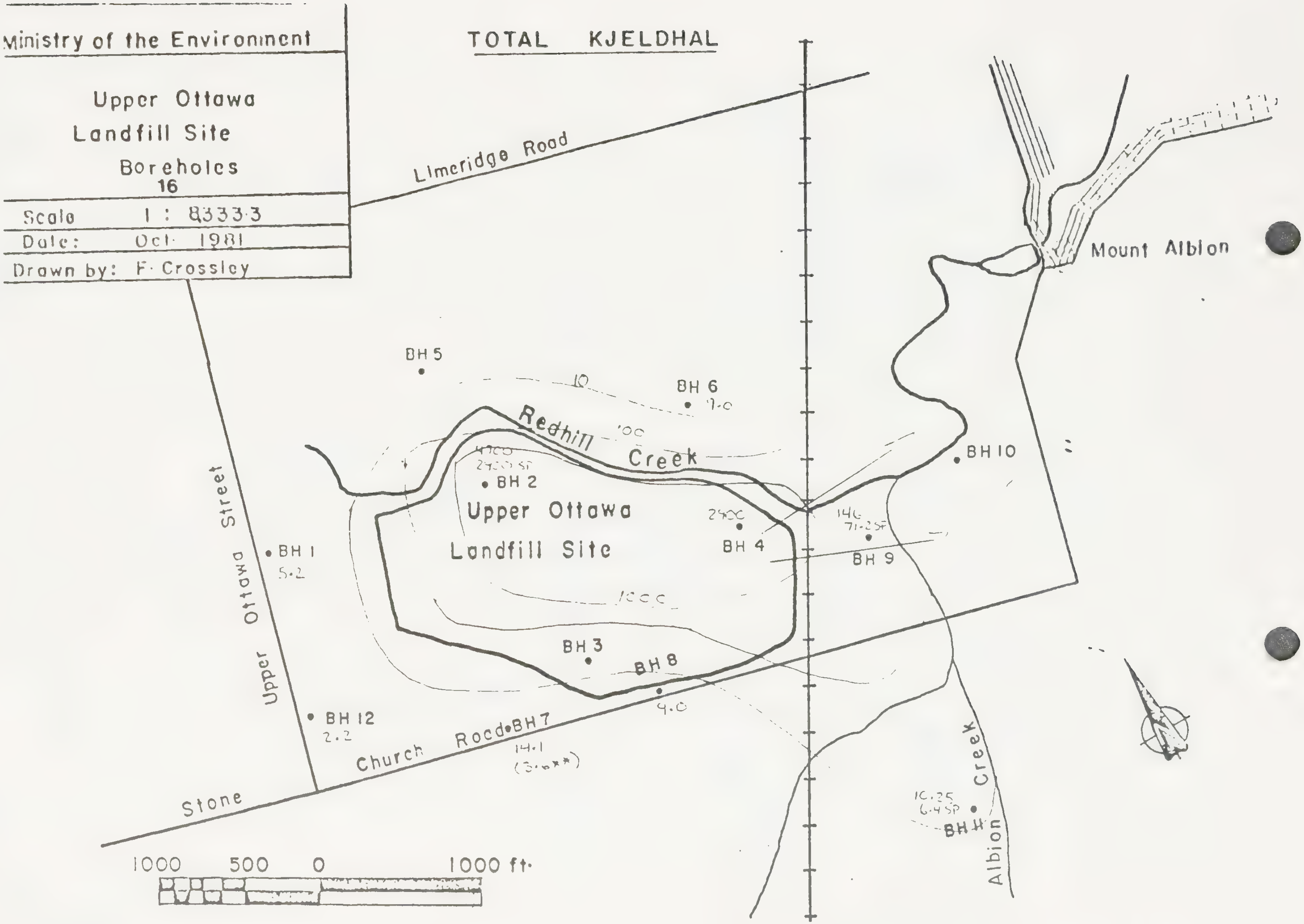
Ministry of the Environment

Upper Ottawa
Landfill Site
Boreholes
15

Scale 1 : 8333.3
Date: Oct. 1981
Drawn by: F. Crossley

Figure #15

TOTAL KJELDHAL



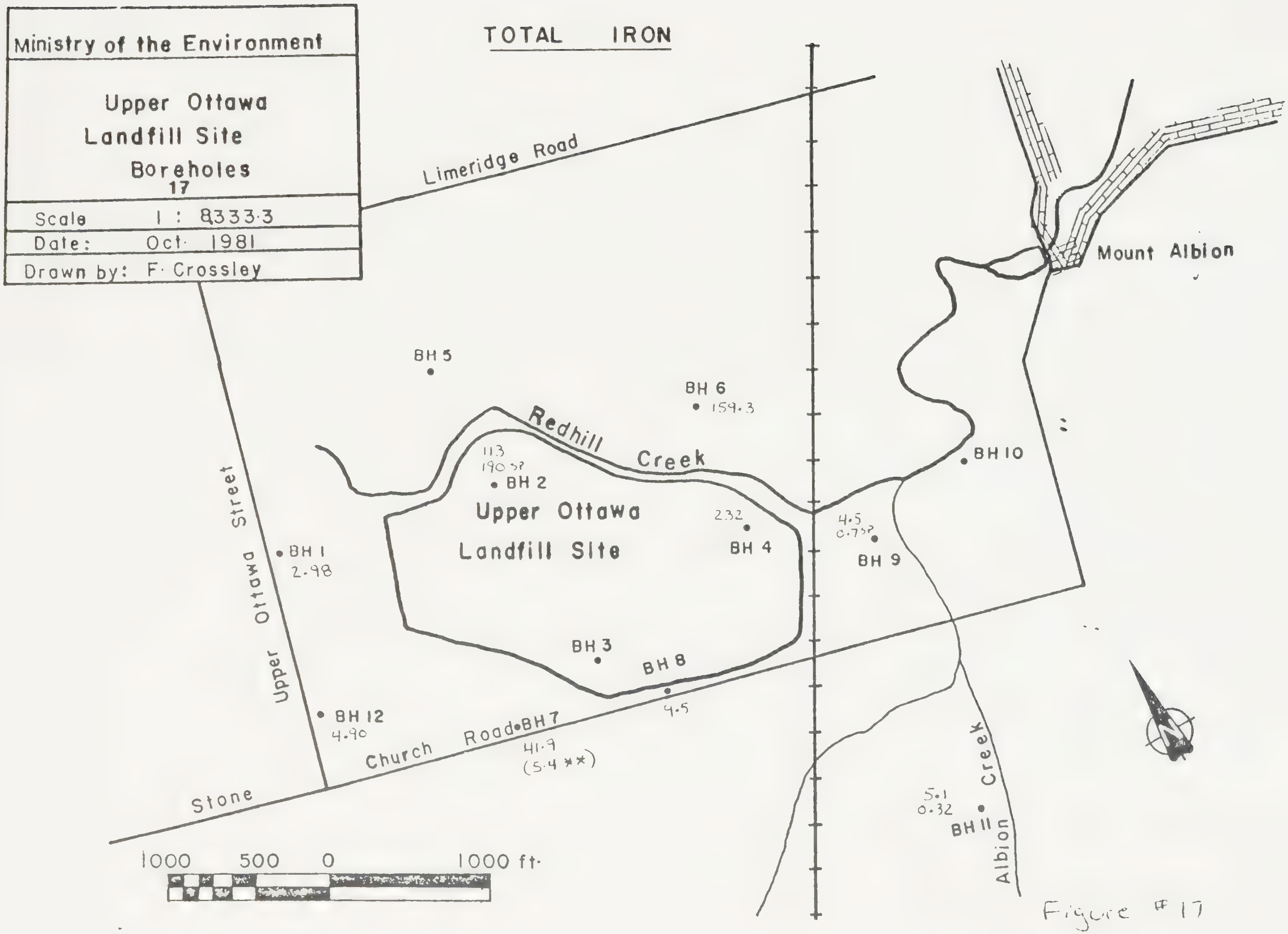
Ministry of the Environment

Upper Ottawa
Landfill Site
Boreholes
16

Scale 1 : 8333.3
Date: Oct. 1981
Drawn by: F. Crossley

Figure # 16

TOTAL IRON



Ministry of the Environment

Upper Ottawa
Landfill Site
Boreholes
17

Scale 1 : 8333.3
Date: Oct. 1981
Drawn by: F. Crossley

Figure # 17

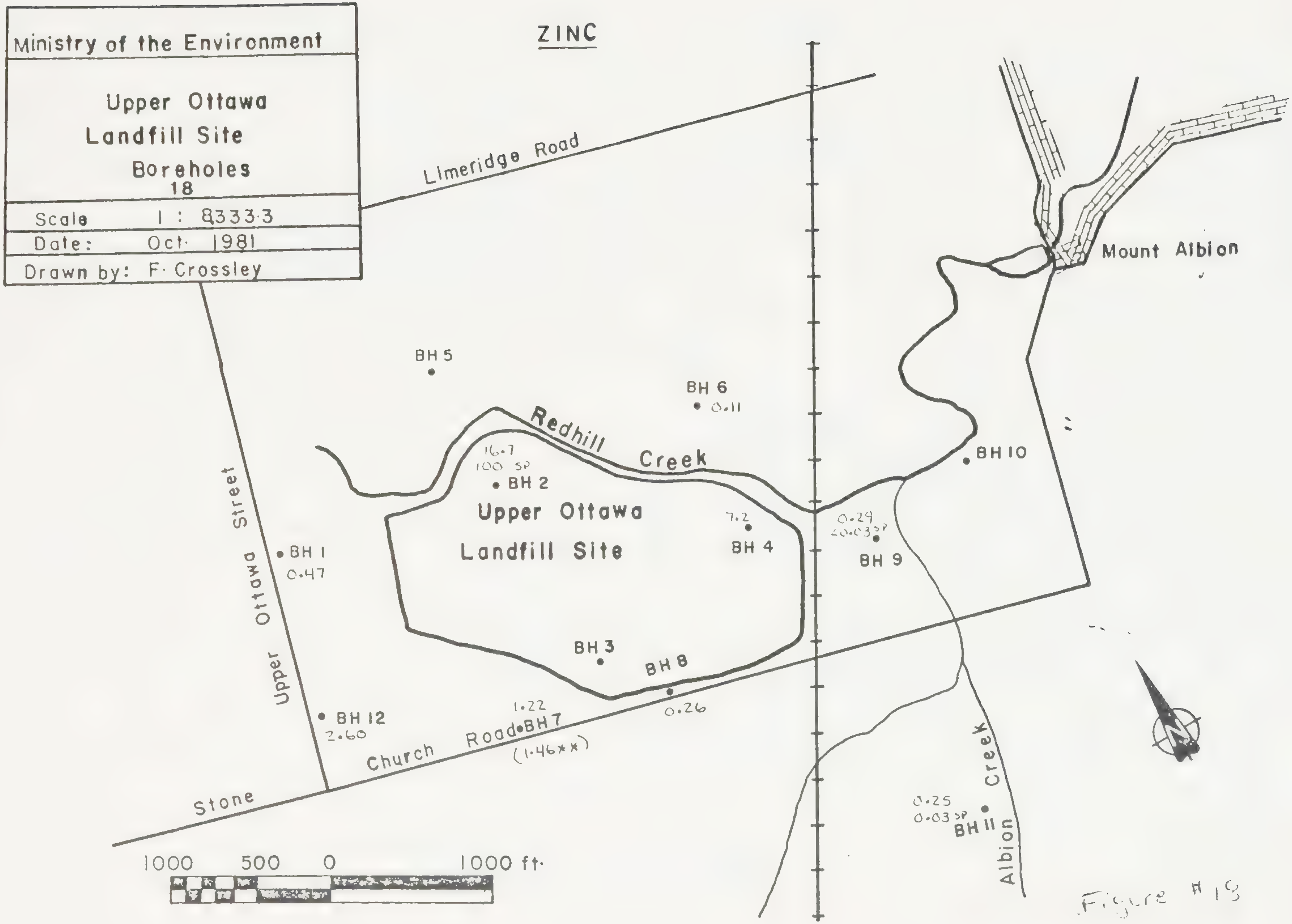
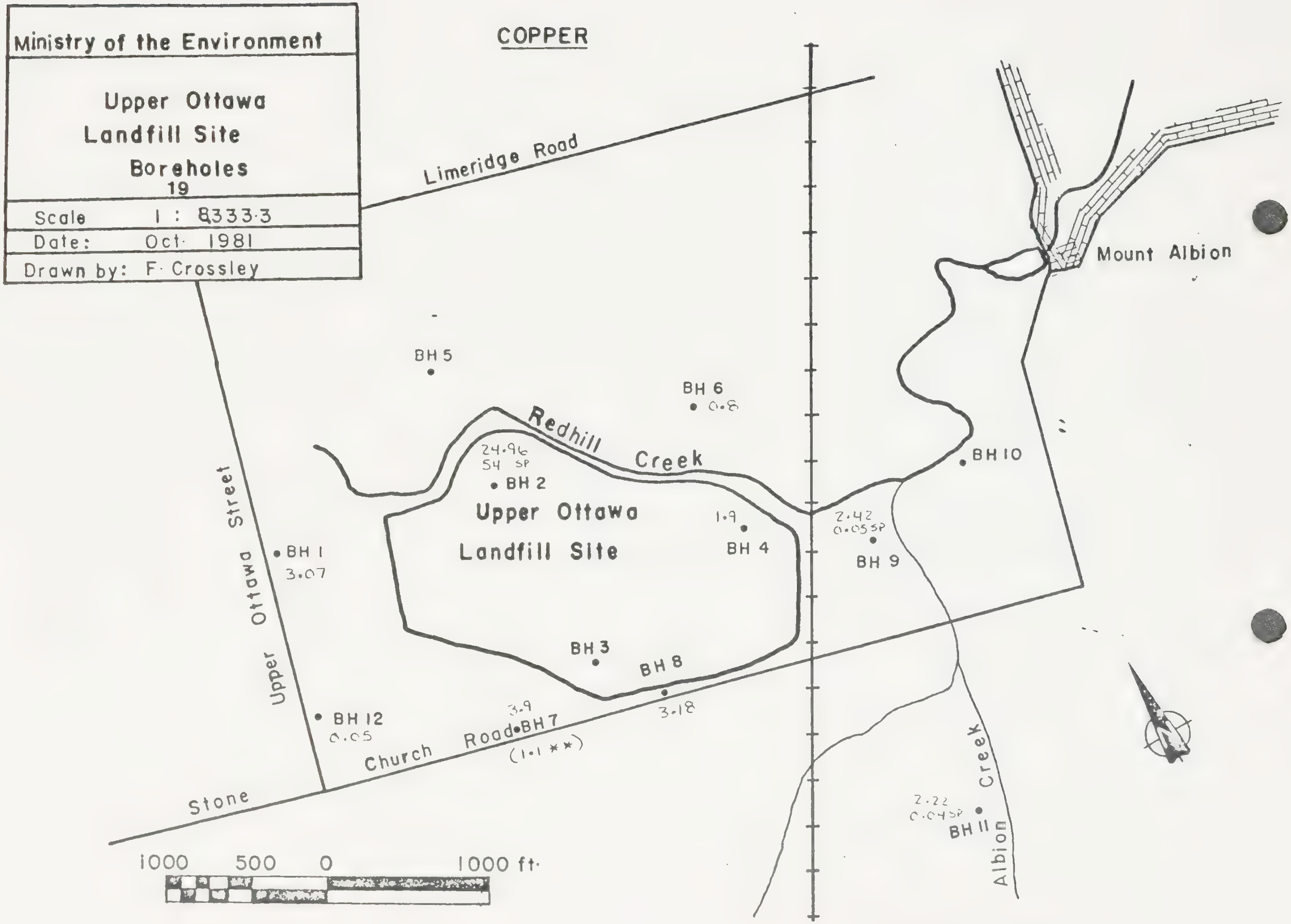

Ministry of the Environment
Upper Ottawa
Landfill Site
Boreholes
18
Scale 1 : 8333.3
Date: Oct. 1981
Drawn by: F. Crossley
ZINC
Limeridge Road
Mount Albion
Upper Ottawa Street
Stone Church Road
Redhill Creek
Albion Creek
Upper Ottawa
Landfill Site
BH 1
0.47
BH 2
16.7
100 sp
BH 3
BH 4
7.2
BH 5
BH 6
0.11
BH 7
1.22
(1.46**)
BH 8
0.26
BH 9
0.29
<0.03 sp
BH 10
BH 11
0.25
0.03 sp
BH 12
2.60
N
1000
500
0
1000 ft.

Figure #18

COPPER


Ministry of the Environment

Upper Ottawa
Landfill Site
Boreholes
19

Scale 1 : 8333.3
Date: Oct. 1981
Drawn by: F. Crossley

Figure # 14

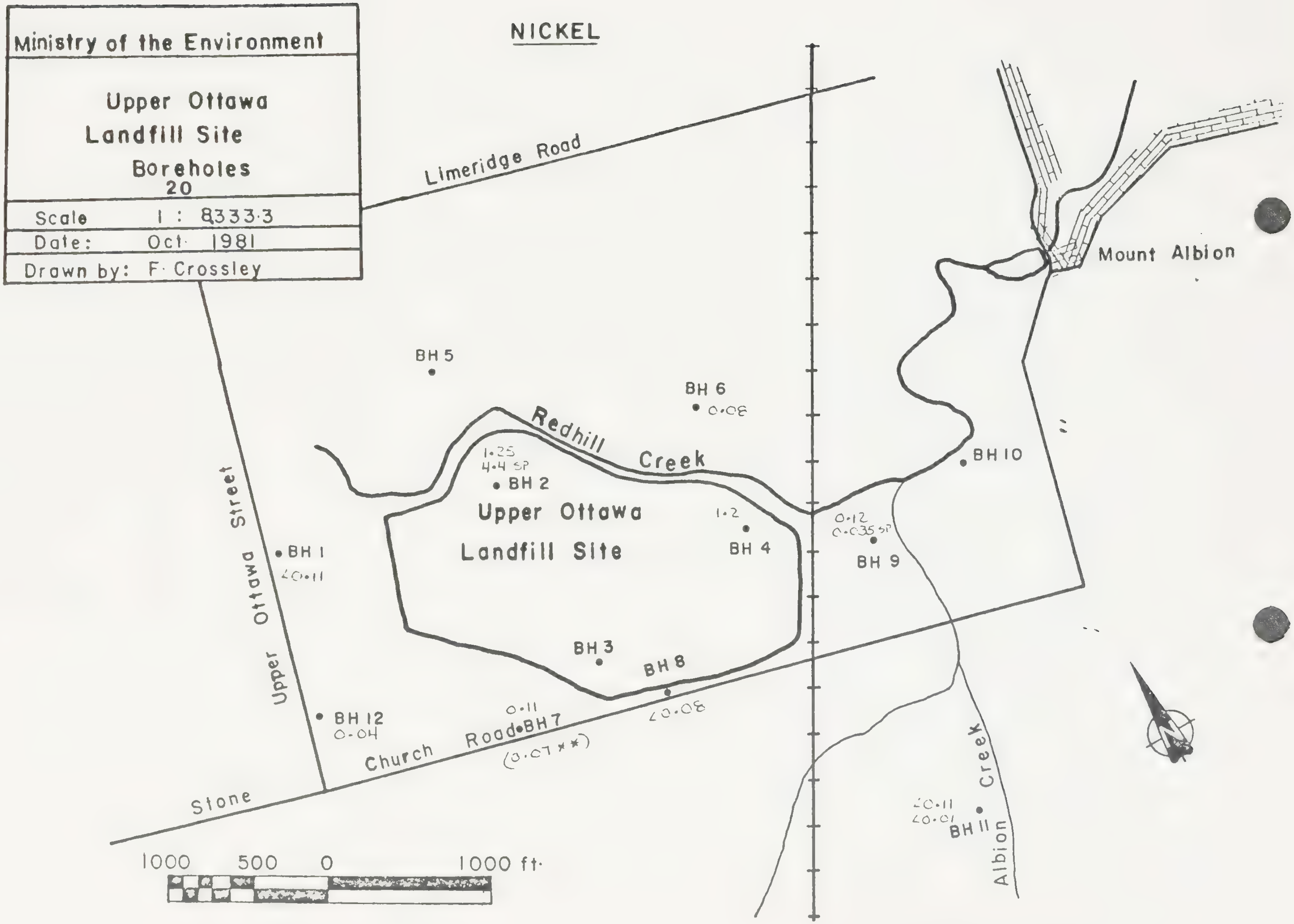
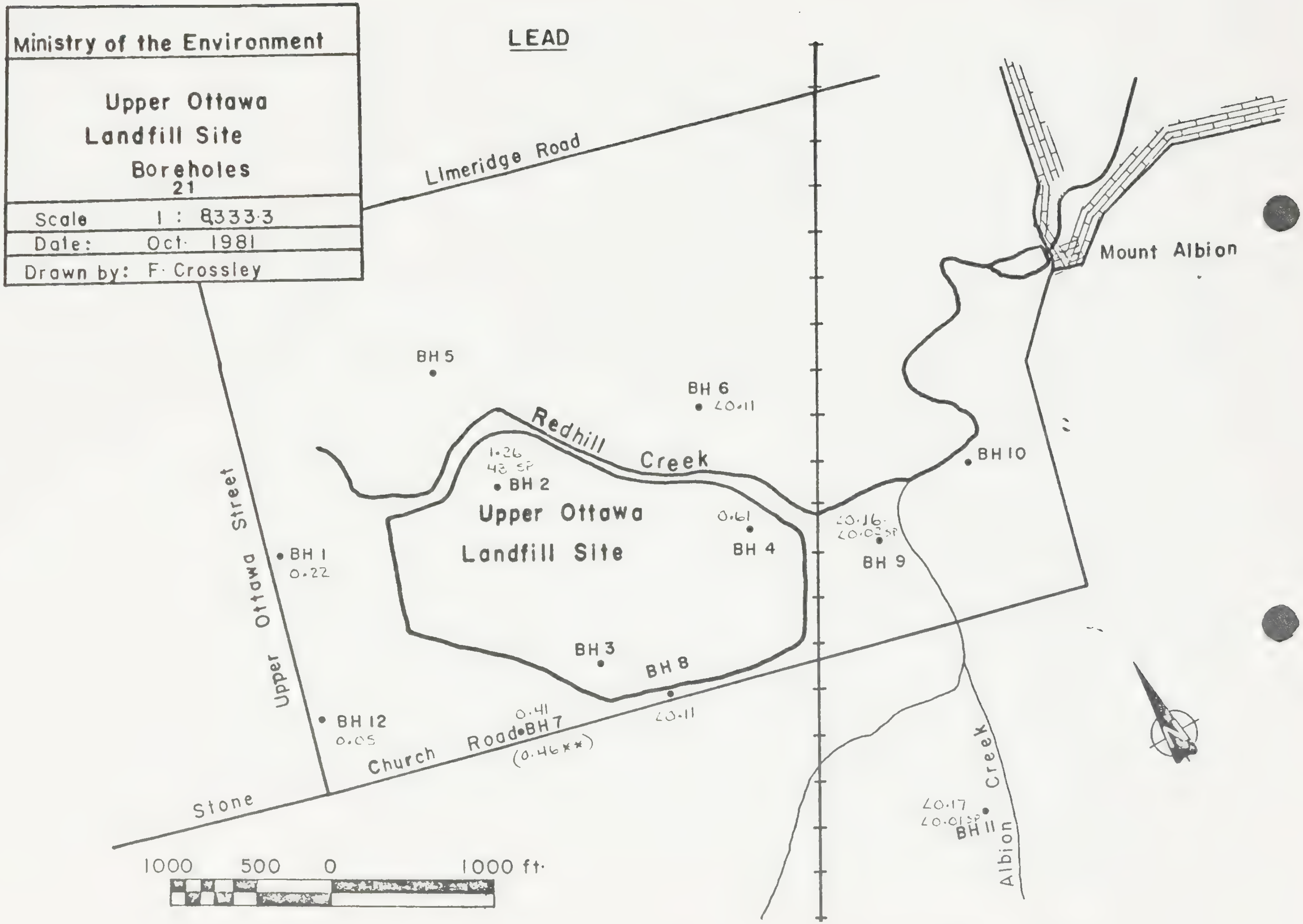

Ministry of the Environment
Upper Ottawa
Landfill Site
Boreholes
20
Scale 1 : 8333.3
Date: Oct. 1981
Drawn by: F. Crossley
NICKEL
Limeridge Road
Mount Albion
BH 5
BH 6
0.08
Redhill Creek
1.25
4.4 SP
BH 2
Upper Ottawa Landfill Site
1.2
BH 4
BH 10
0.12
0.035 SP
BH 9
Upper Ottawa Street
BH 1
<0.11
BH 3
BH 8
<0.08
BH 12
0.04
0.11
BH 7
(0.07**)
Stone Church Road
Albion Creek
<0.11
<0.01
BH 11
1000
500
0
1000 ft.

Figure #10



Ministry of the Environment

Upper Ottawa
Landfill Site
Boreholes
21

Scale 1 : 8333.3
Date: Oct. 1981
Drawn by: F. Crossley

Figure # 21

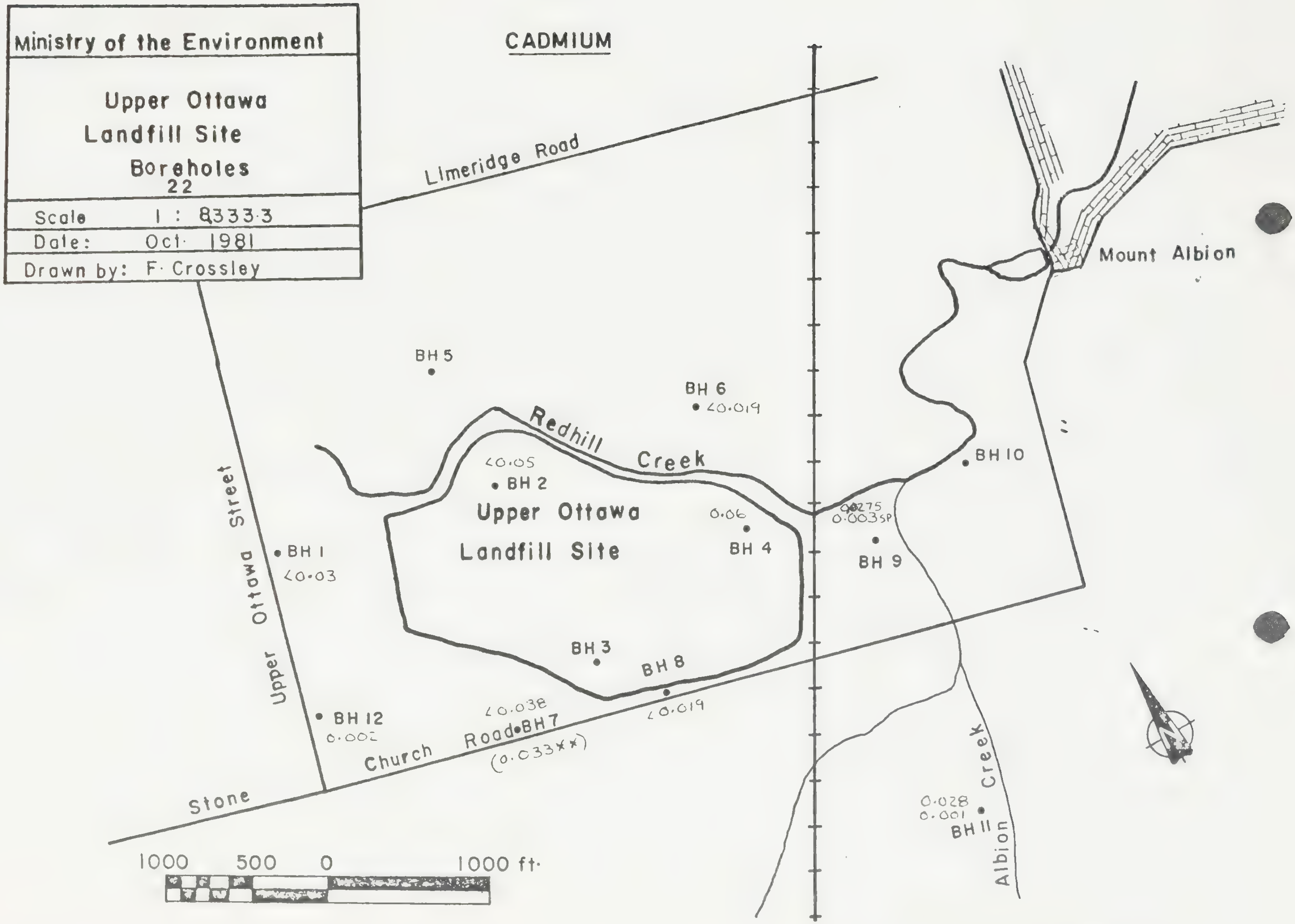

Ministry of the Environment
Upper Ottawa
Landfill Site
Boreholes
22
Scale 1 : 8333.3
Date: Oct. 1981
Drawn by: F. Crossley
CADMIUM
Limeridge Road
Mount Albion
BH 5
BH 6
<0.019
Redhill Creek
BH 10
<0.05
BH 2
Upper Ottawa
Landfill Site
0.06
BH 4
0.0275
0.003SP
BH 9
BH 1
<0.03
Upper Ottawa Street
BH 3
BH 8
<0.019
BH 12
0.002
<0.038
BH7
(0.033**)
Stone Church Road
Albion Creek
0.028
0.001
BH 11
1000 500 0 1000 ft.

Figure #32

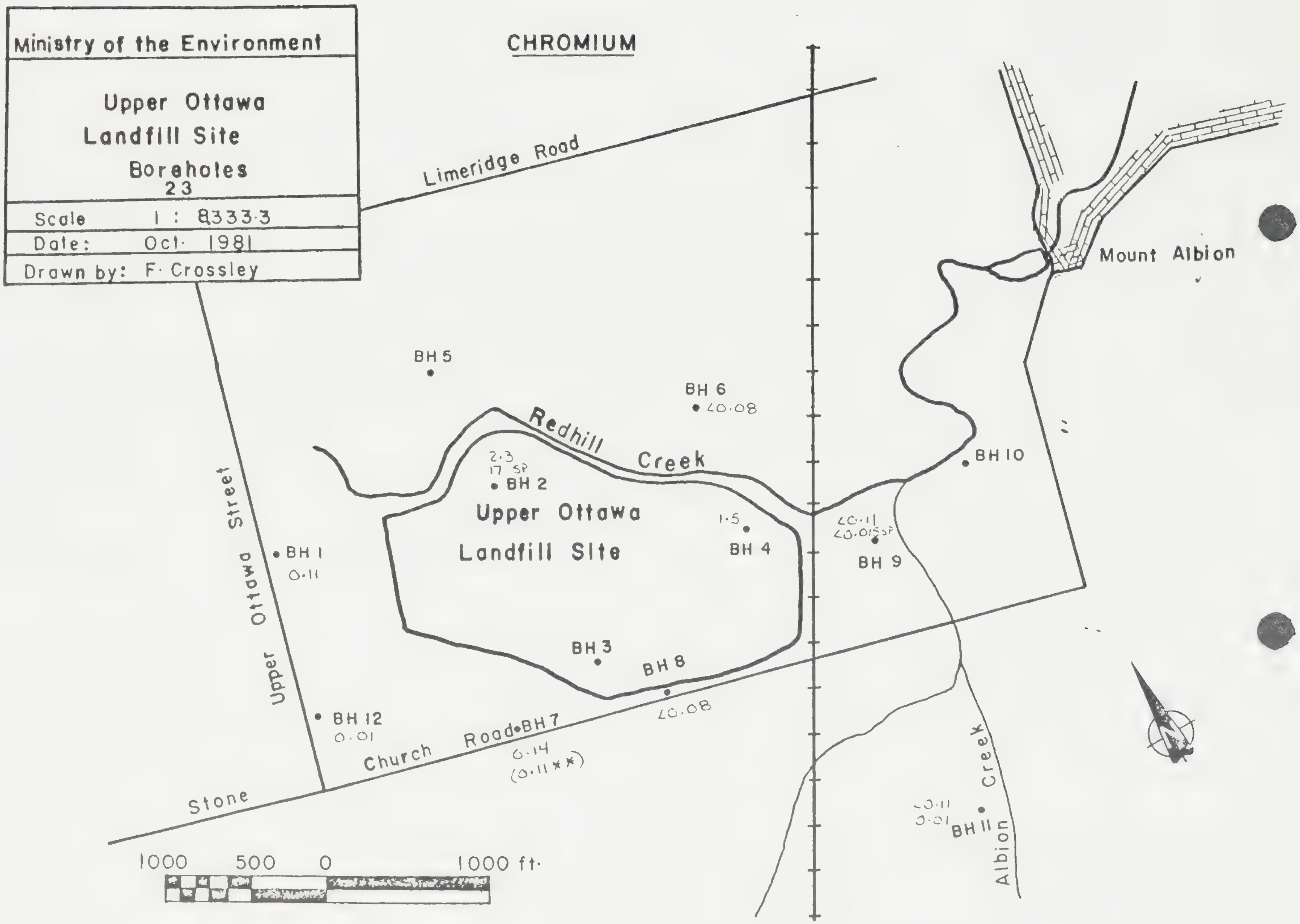
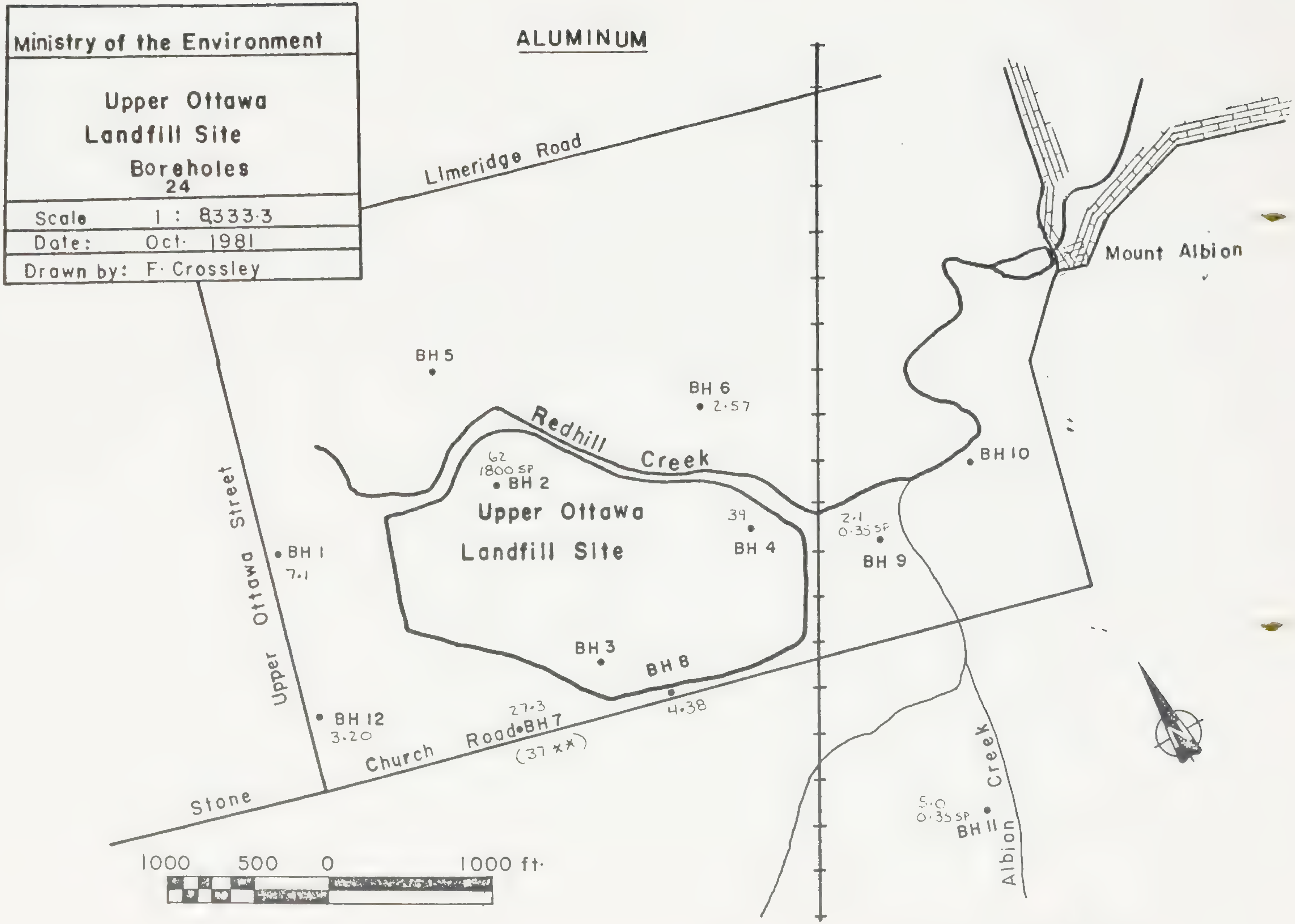

Ministry of the Environment
Upper Ottawa
Landfill Site
Boreholes
23
Scale 1 : 8333·3
Date: Oct· 1981
Drawn by: F· Crossley
CHROMIUM
Limeridge Road
Upper Ottawa Street
Stone Church Road
Redhill Creek
Albion Creek
Mount Albion
Upper Ottawa
Landfill Site
BH 1
0·11
BH 2
2·3
17 SP
BH 3
BH 4
1·5
BH 5
BH 6
∠0·08
BH 7
0·14
(0·11**)
BH 8
∠0·08
BH 9
∠0·11
∠0·015SP
BH 10
BH 11
∠0·11
0·01
BH 12
0·01
1000
500
0
1000 ft·

Figure # 23

ALUMINUM



Ministry of the Environment

Upper Ottawa
Landfill Site
Boreholes
24

Scale 1 : 8333.3
Date: Oct. 1981
Drawn by: F. Crossley

Figure # 24

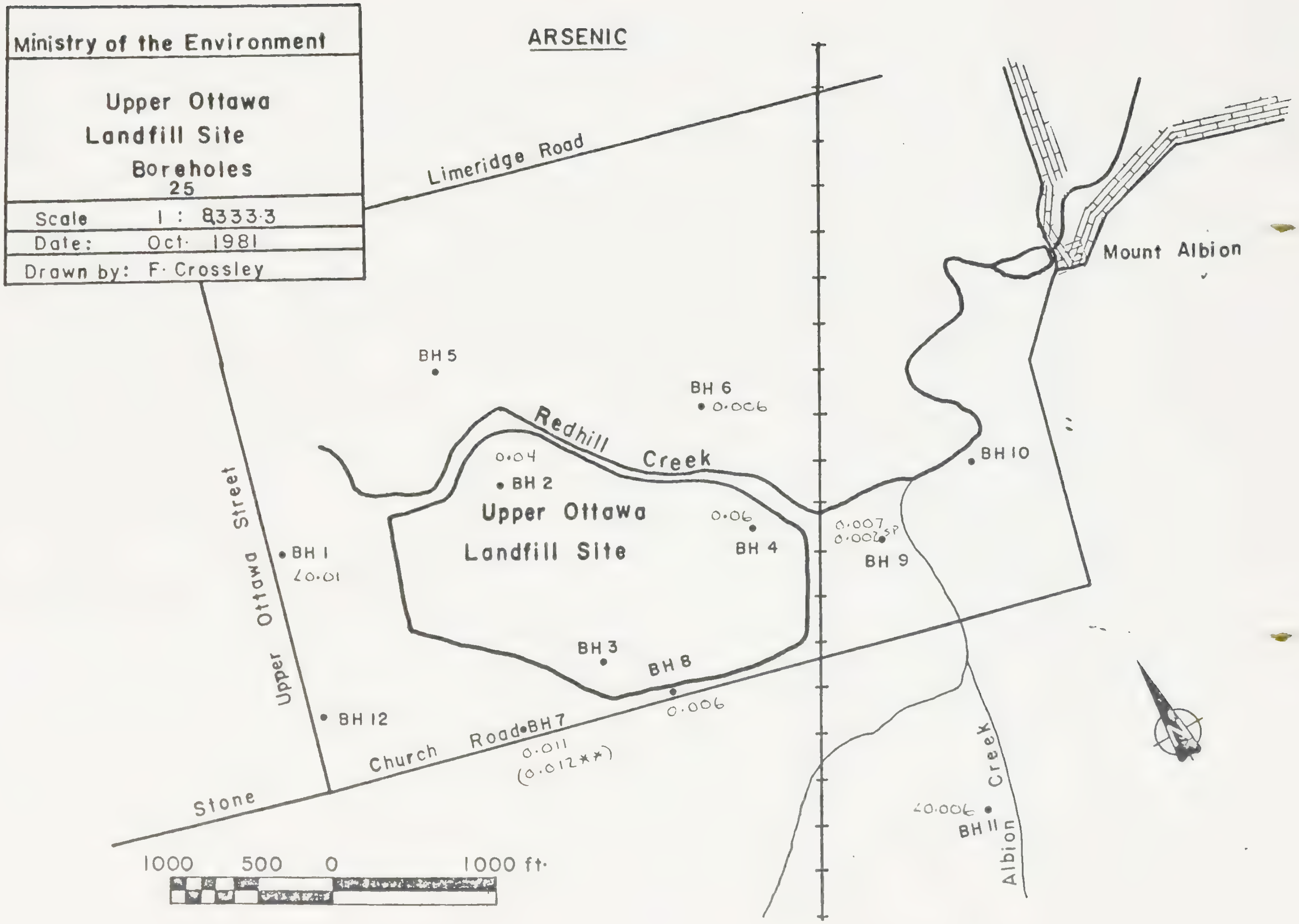

Ministry of the Environment
Upper Ottawa
Landfill Site
Boreholes
25
Scale 1 : 8333.3
Date: Oct. 1981
Drawn by: F. Crossley
ARSENIC
Limeridge Road
Mount Albion
BH 5
BH 6
0.006
Redhill Creek
0.04
BH 2
Upper Ottawa
Landfill Site
0.06
BH 4
0.007
0.002SP
BH 9
BH 10
BH 1
<0.01
BH 3
BH 8
0.006
BH 12
Upper Ottawa Street
Stone Church Road
BH 7
0.011
(0.012**)
<0.006
BH 11
Albion Creek
1000 500 0 1000 ft.

Figure #25

MANGANESE

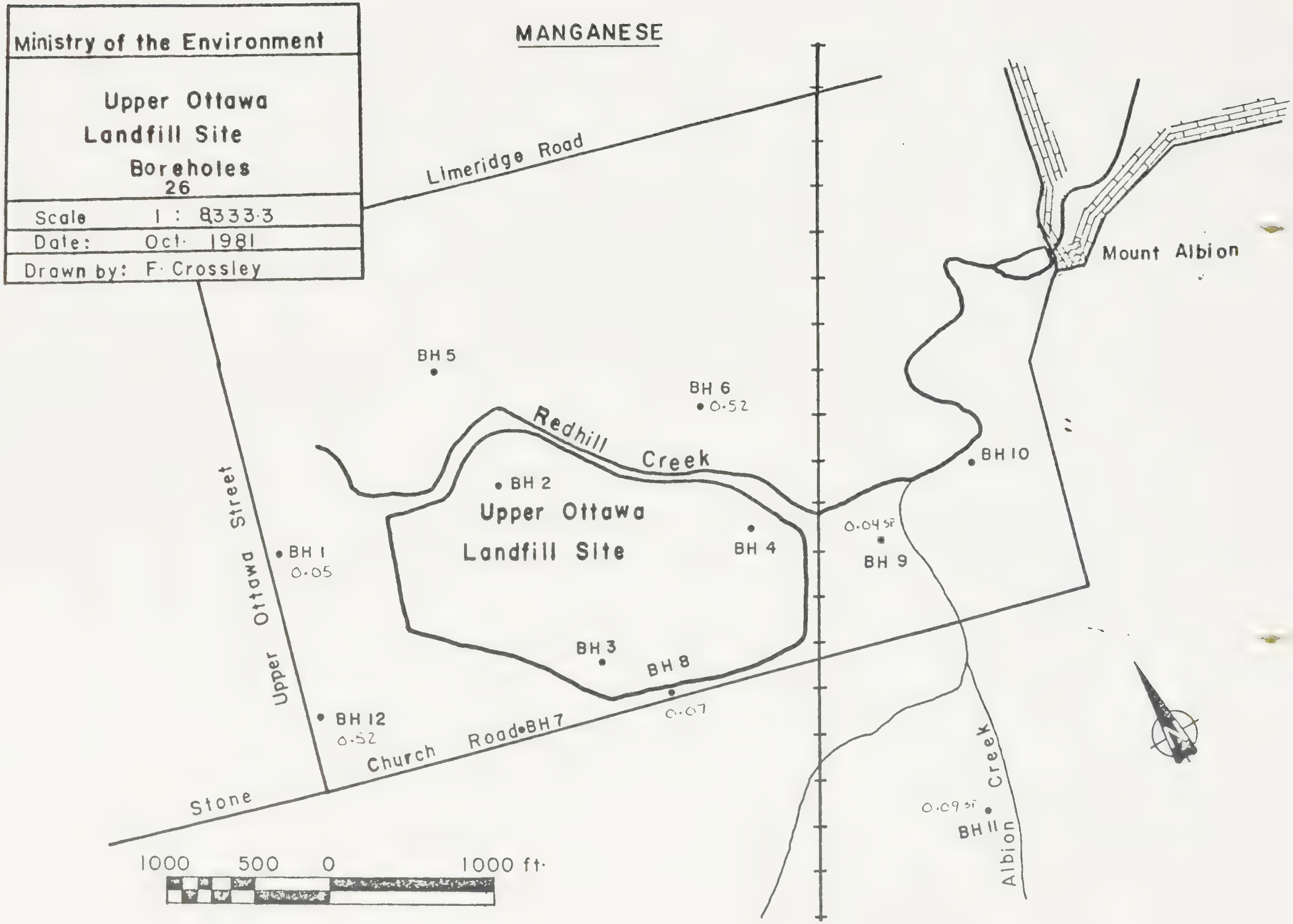
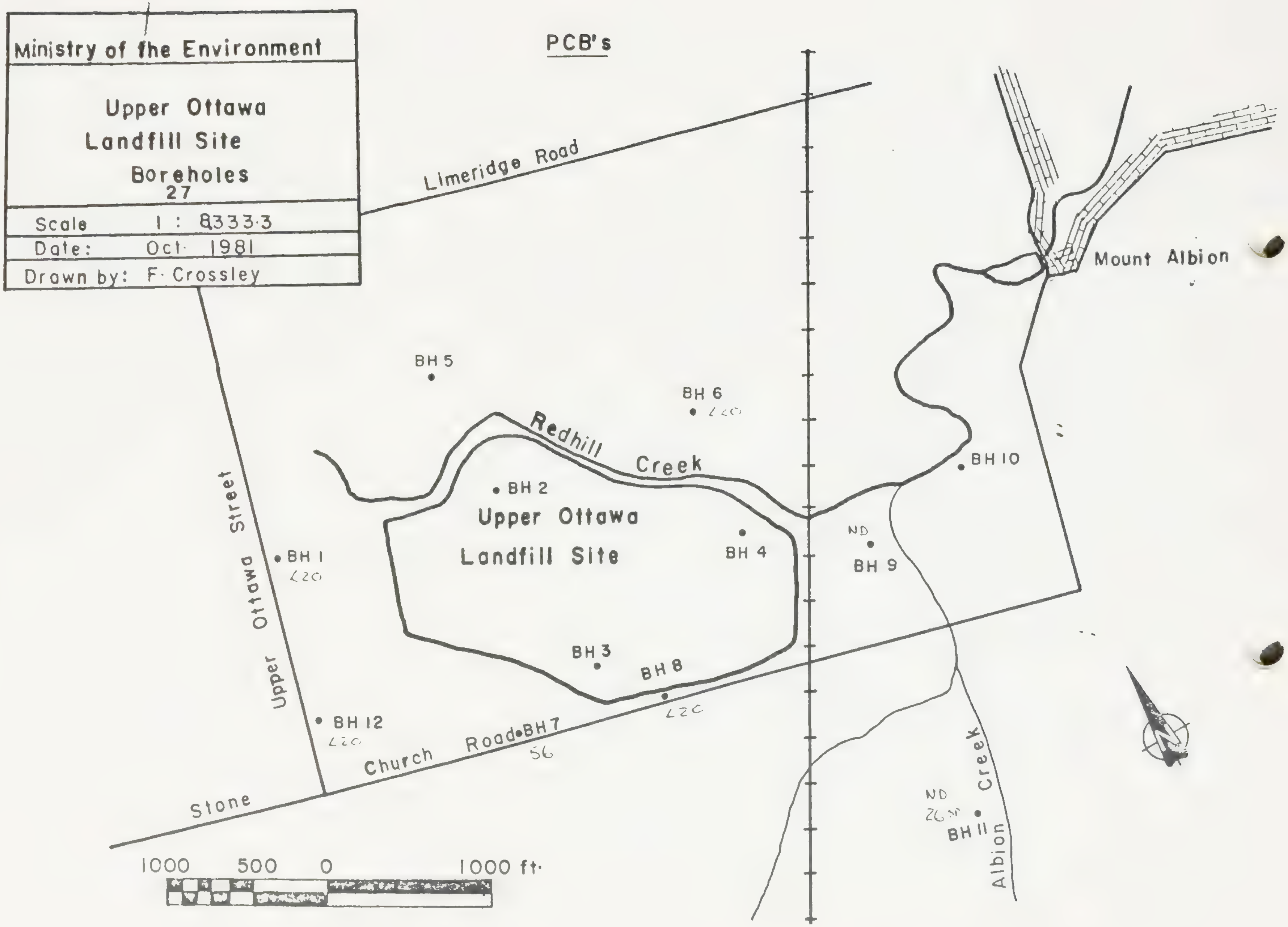


Figure II 26

PCB's



Ministry of the Environment

Upper Ottawa
Landfill Site
Boreholes
27

Scale 1 : 8333.3
Date: Oct. 1981
Drawn by: F. Crossley

Figure 11.33

PHENOLS

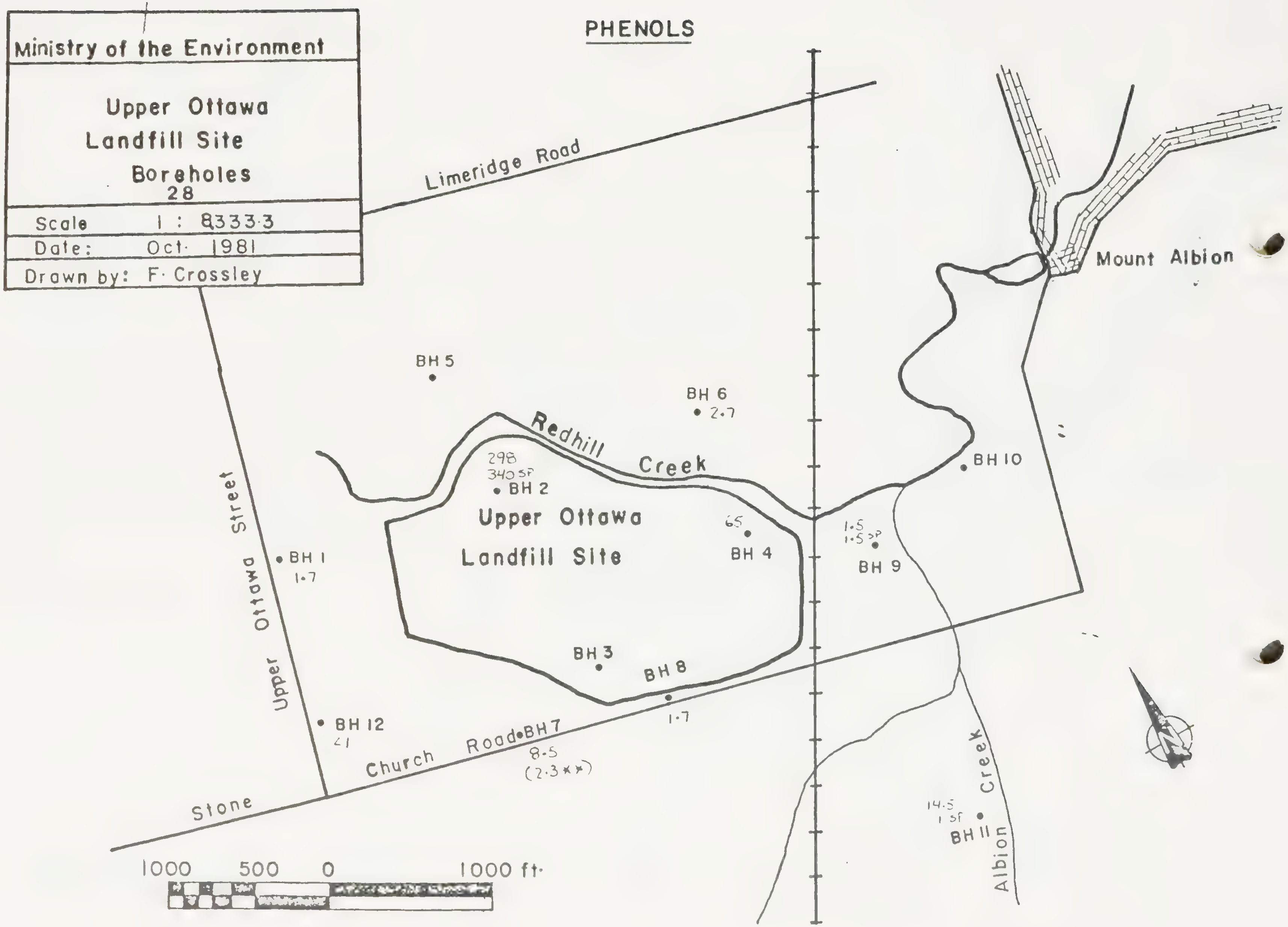
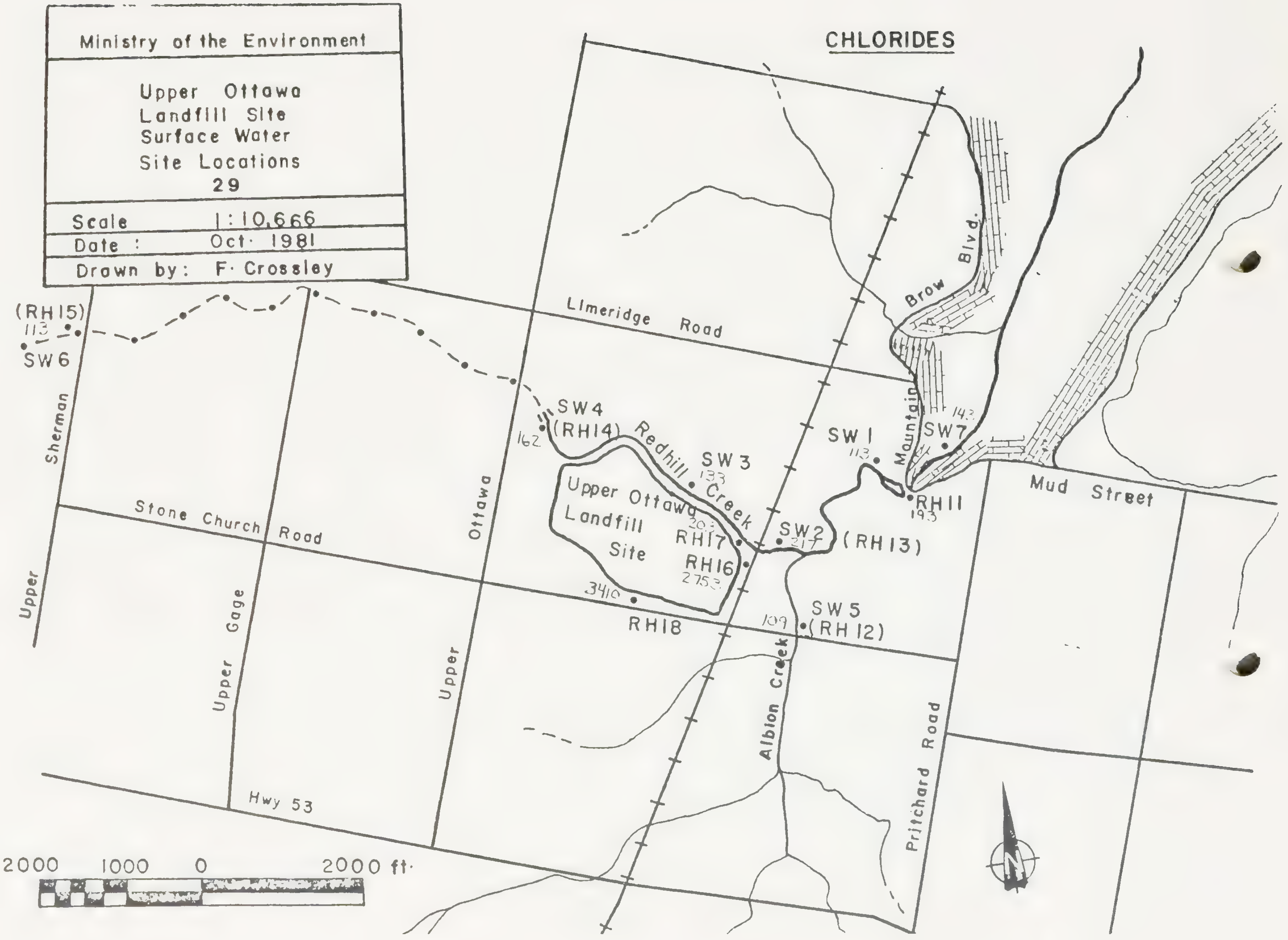


Figure #28



CHLORIDES

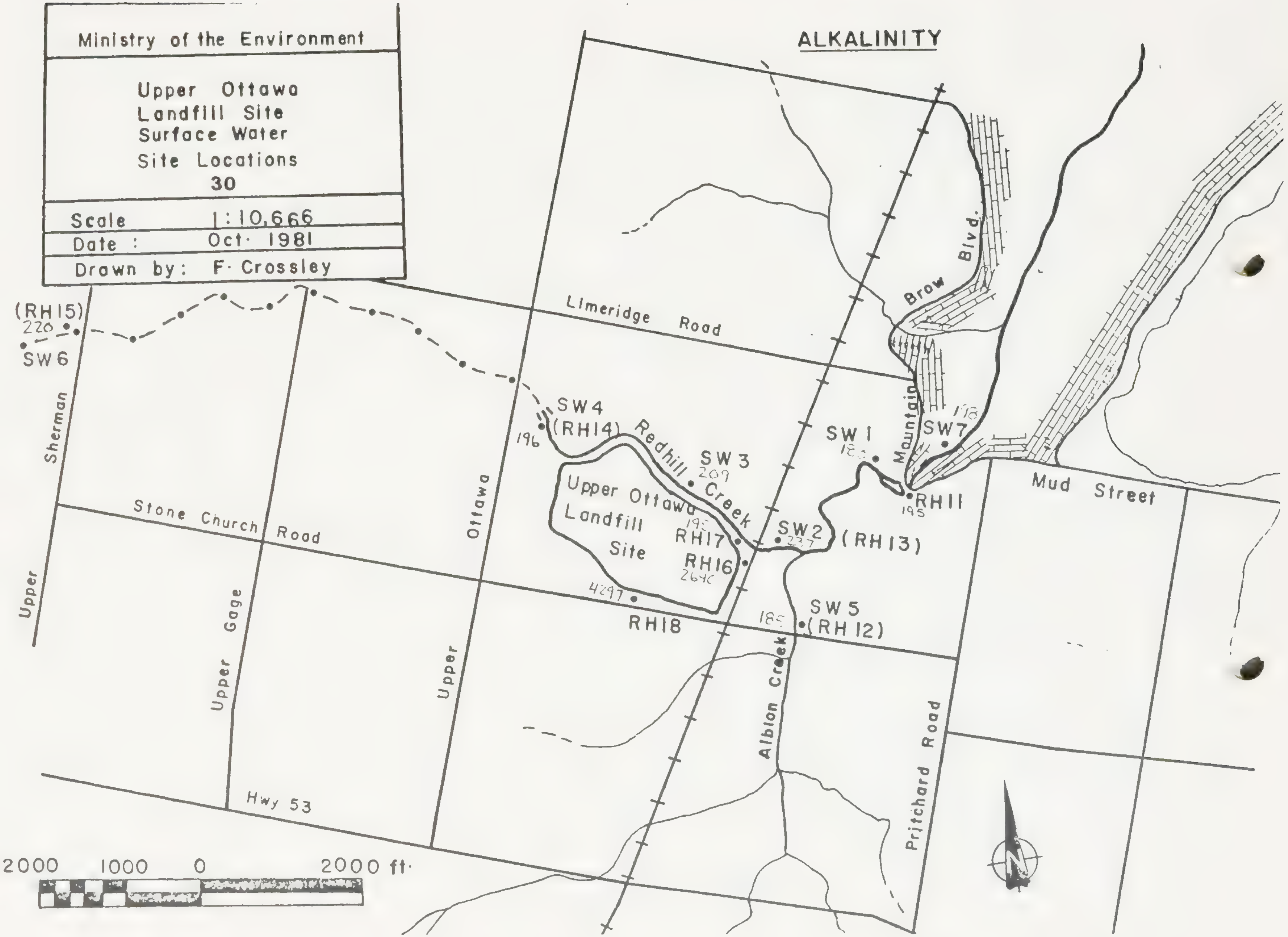
Ministry of the Environment

Upper Ottawa
Landfill Site
Surface Water
Site Locations
29

Scale	1:10,666
Date :	Oct. 1981
Drawn by:	F. Crossley

Figure #29

ALKALINITY

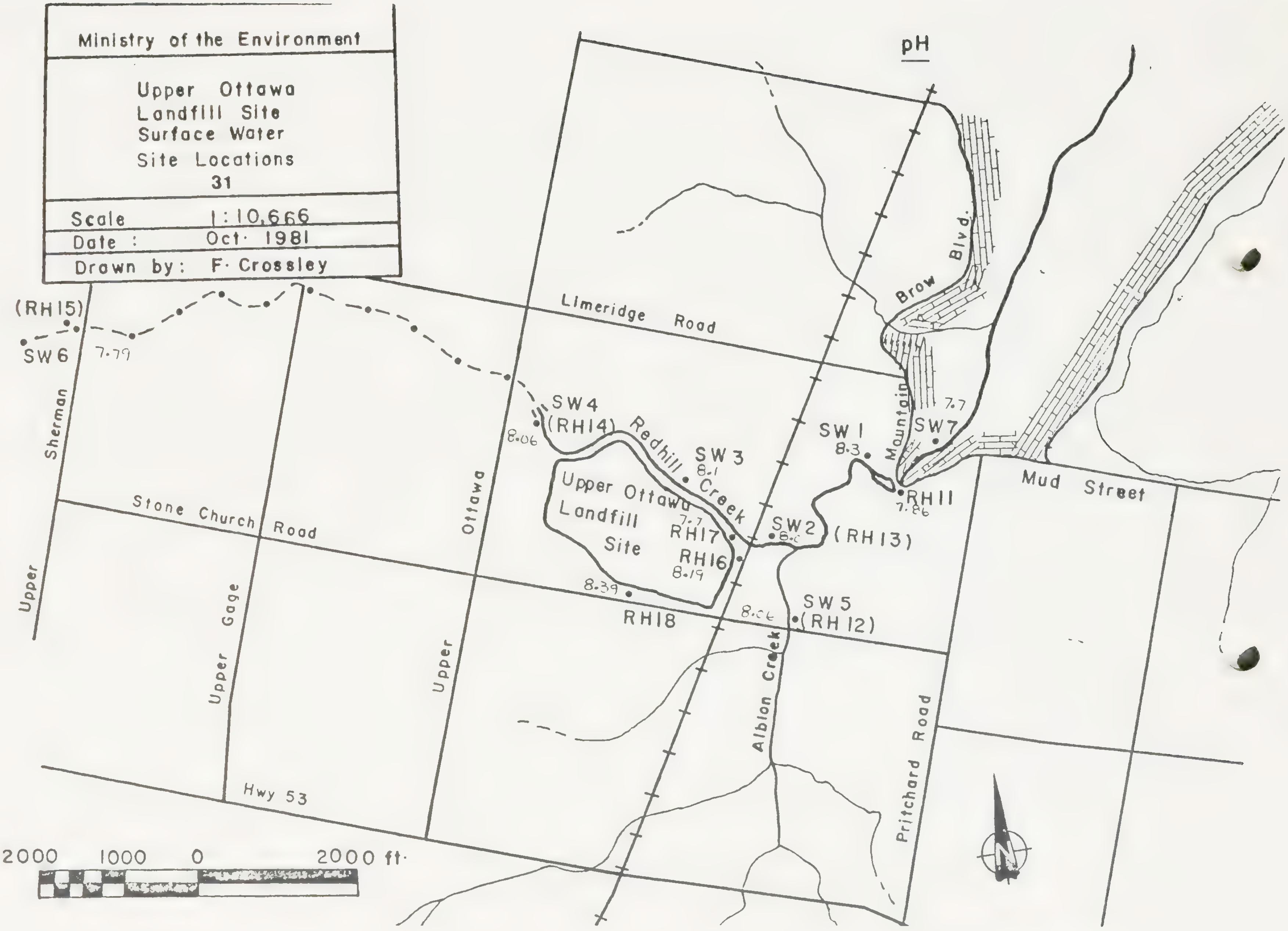


Ministry of the Environment

Upper Ottawa
Landfill Site
Surface Water
Site Locations
30

Scale 1:10,666
Date : Oct· 1981
Drawn by: F· Crossley

Figure # 30



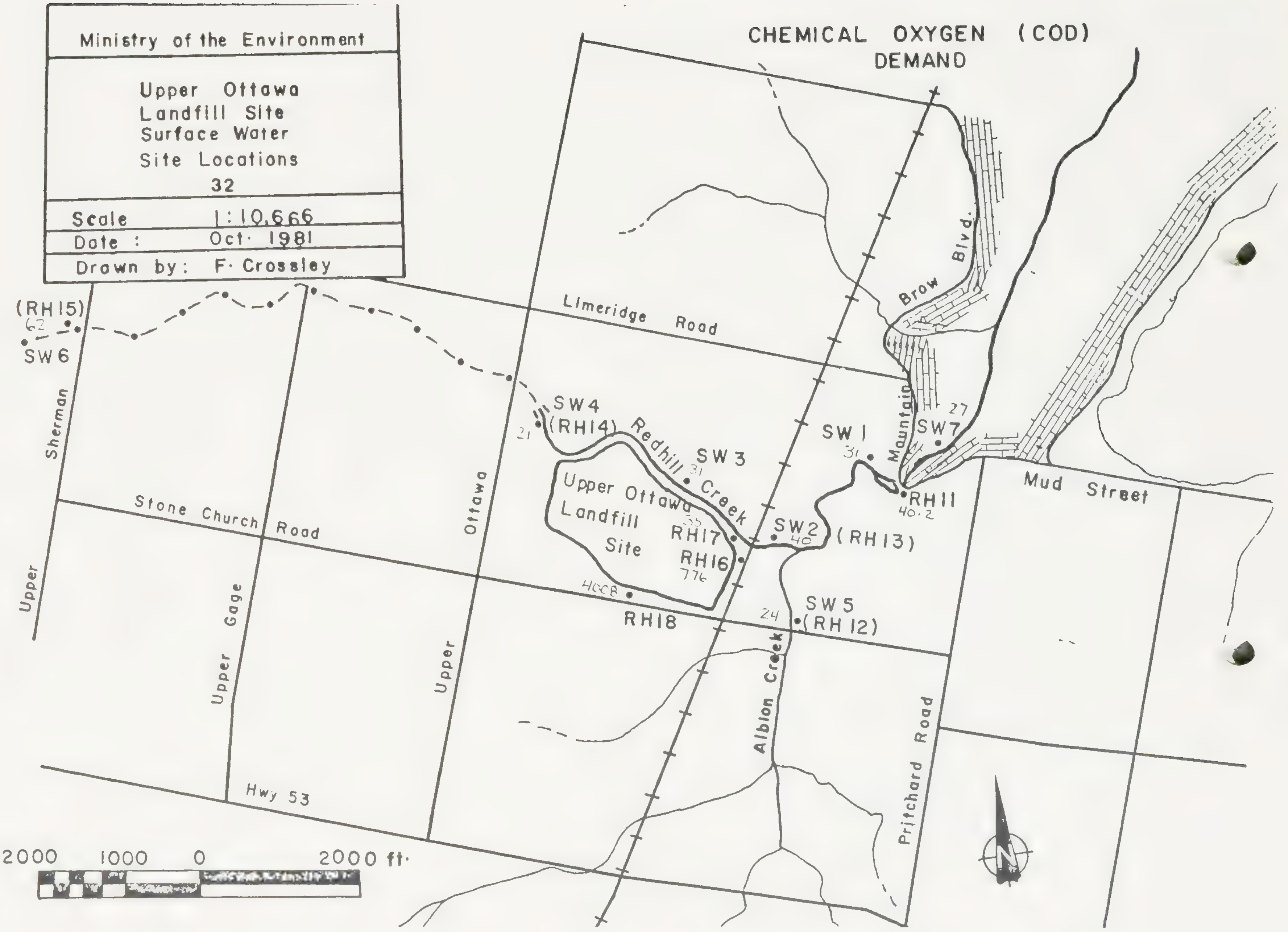
Ministry of the Environment

Upper Ottawa
Landfill Site
Surface Water
Site Locations
31

Scale 1:10,666
Date : Oct. 1981
Drawn by: F. Crossley

Figure A 31

CHEMICAL OXYGEN DEMAND (COD)



Ministry of the Environment

Upper Ottawa
Landfill Site
Surface Water
Site Locations
32

Scale 1:10,666
Date : Oct. 1981
Drawn by: F. Crossley

Figure # 32

5 DAY BIOLOGICAL OXYGEN DEMAND (BOD 5)

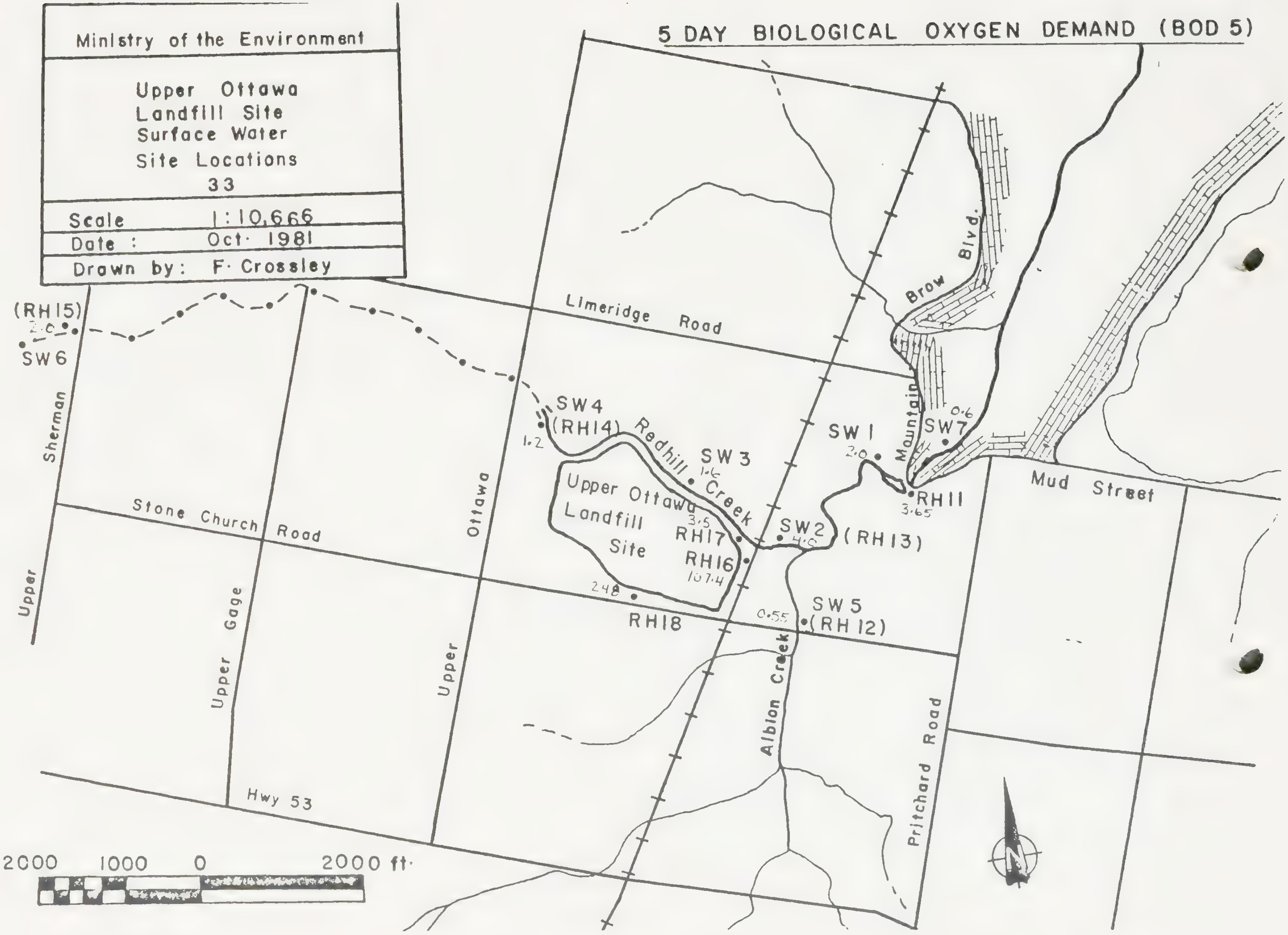


Figure # 33

TOTAL SOLIDS (DISSOLVED SOLIDS)

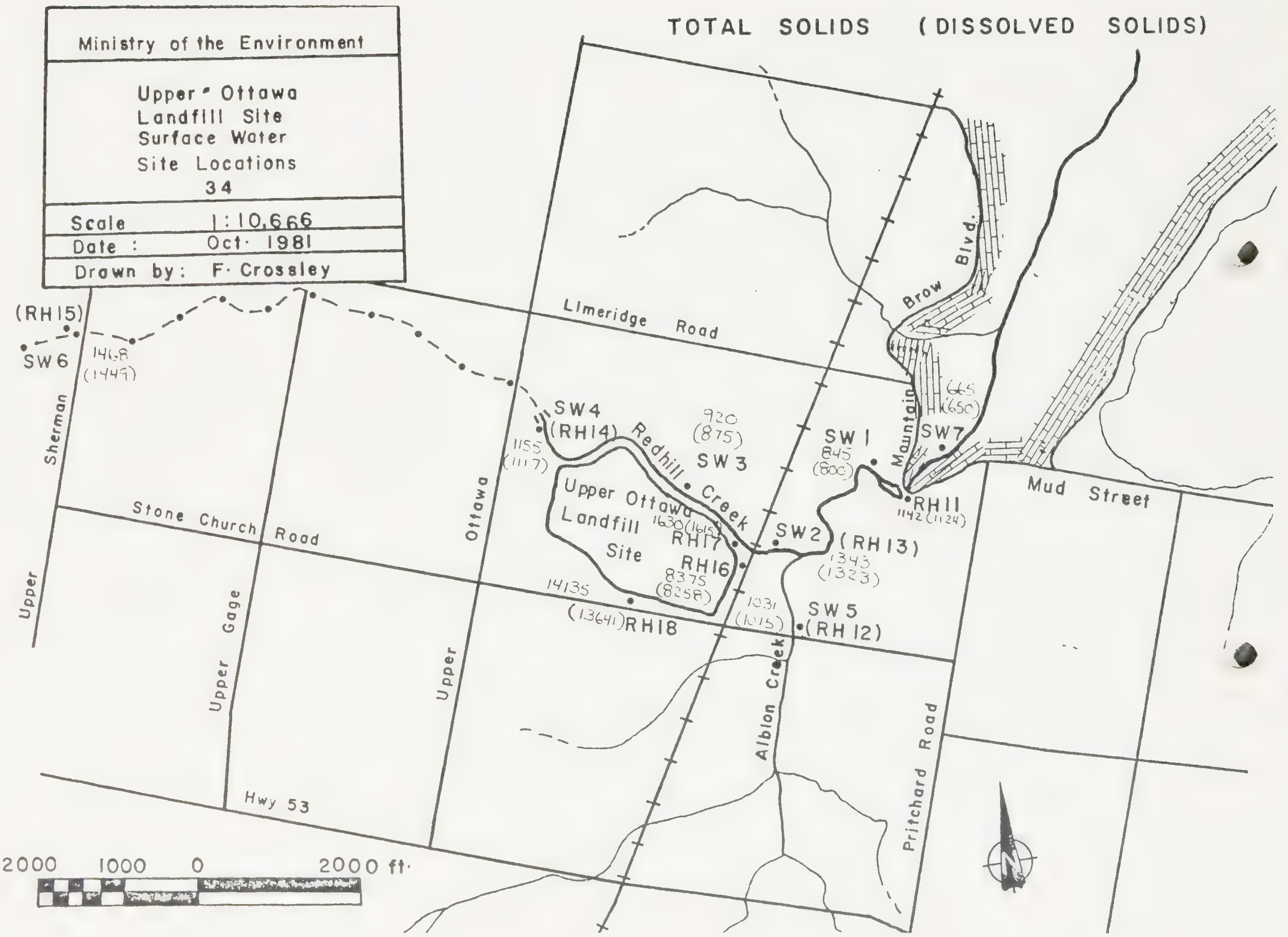


Figure A 34

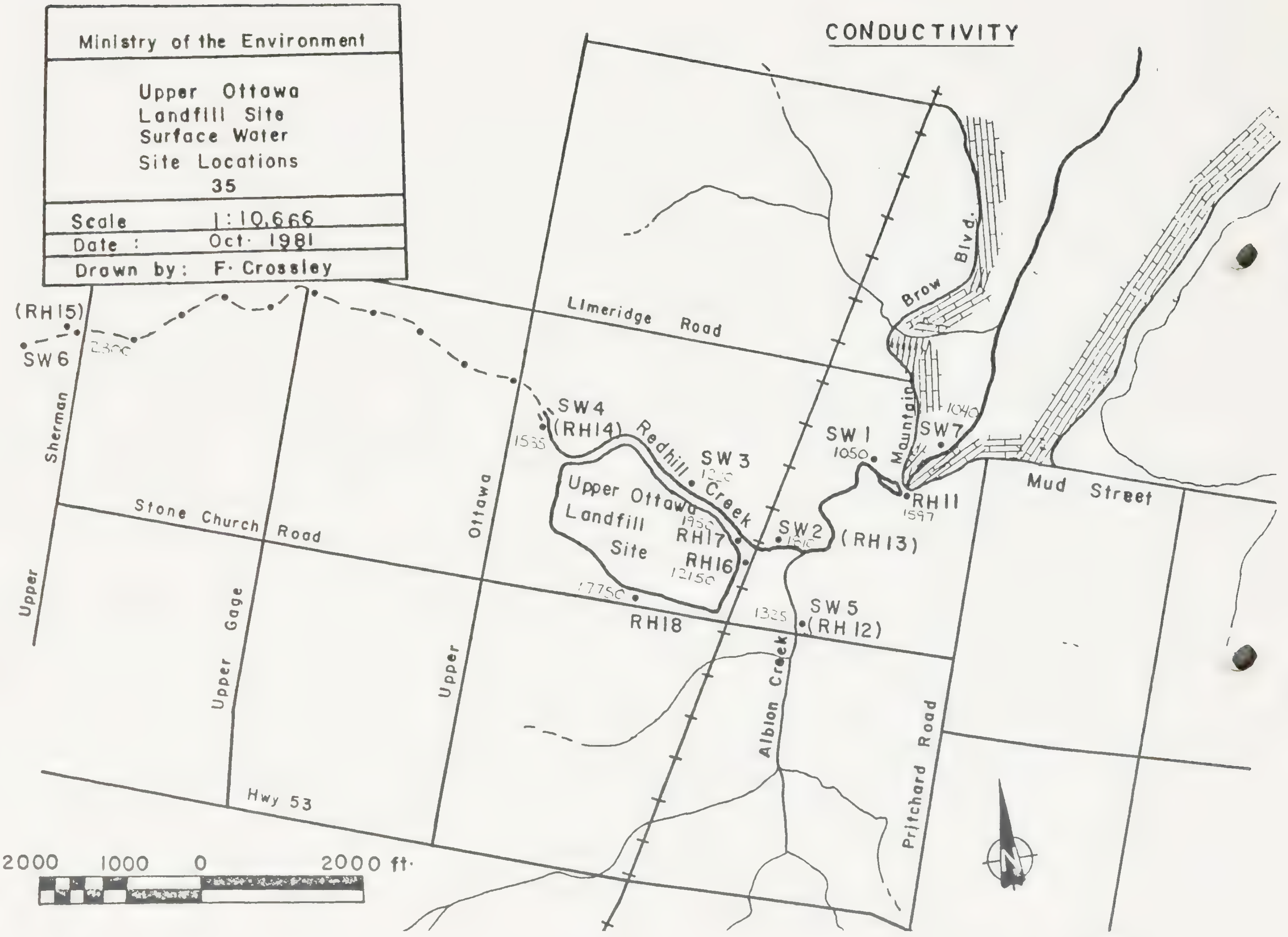
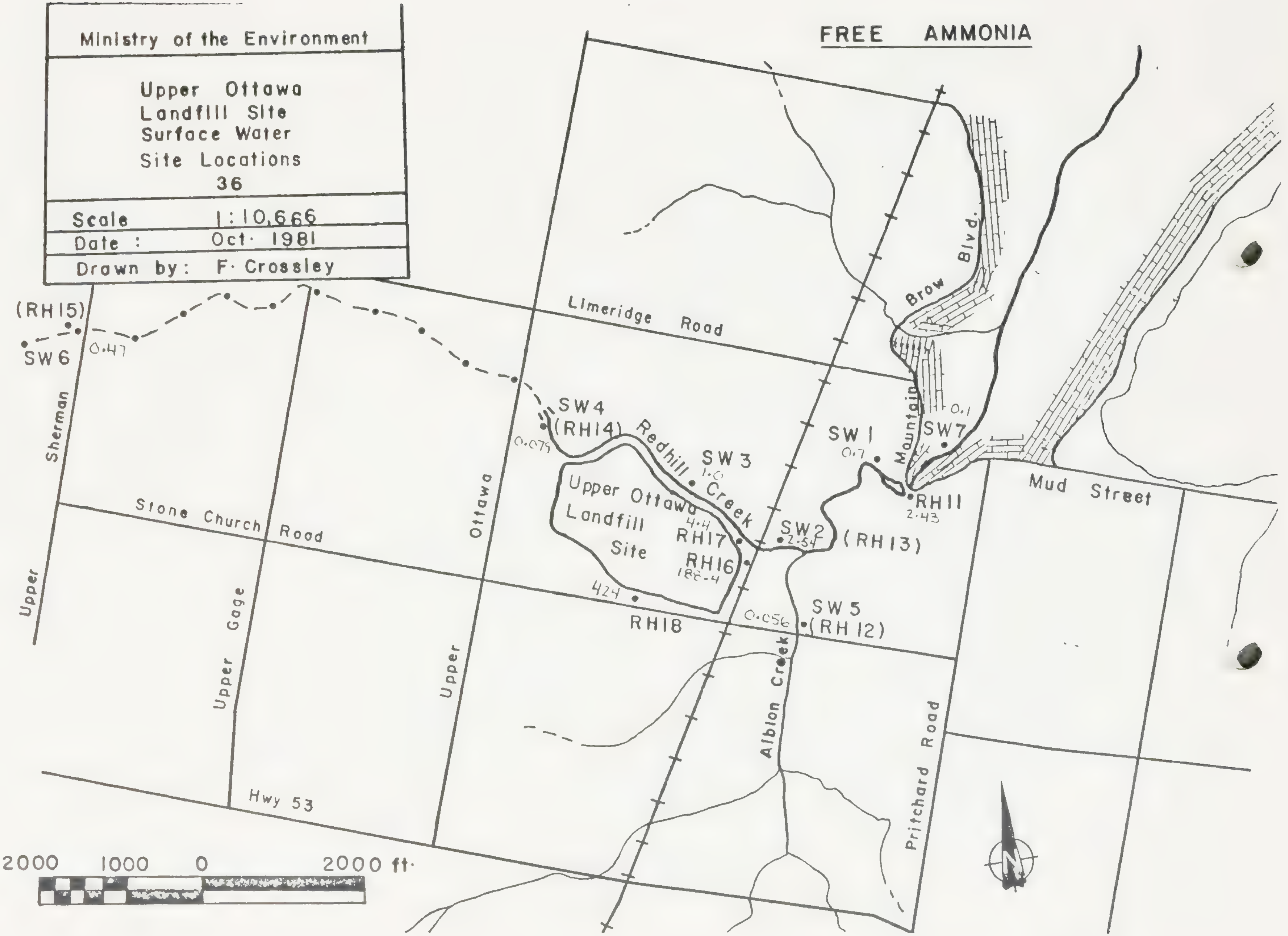

CONDUCTIVITY
Ministry of the Environment
Upper Ottawa
Landfill Site
Surface Water
Site Locations
35
Scale 1:10,666
Date : Oct· 1981
Drawn by: F· Crossley
(RH15)
SW6
2300
Sherman
Upper
Limeridge Road
Stone Church Road
Upper Gage
Hwy 53
Upper Ottawa
SW4
(RH14)
1535
Redhill Creek
SW3
1220
Upper Ottawa Landfill Site
1950
RH17
RH16
12150
17750
RH18
SW2
1510
(RH13)
SW1
1050
Mountain Brow Blvd.
1040
SW7
RH11
1597
SW5
(RH12)
1325
Albion Creek
Pritchard Road
Mud Street
N
2000 1000 0 2000 ft·

Figure # 35

FREE AMMONIA



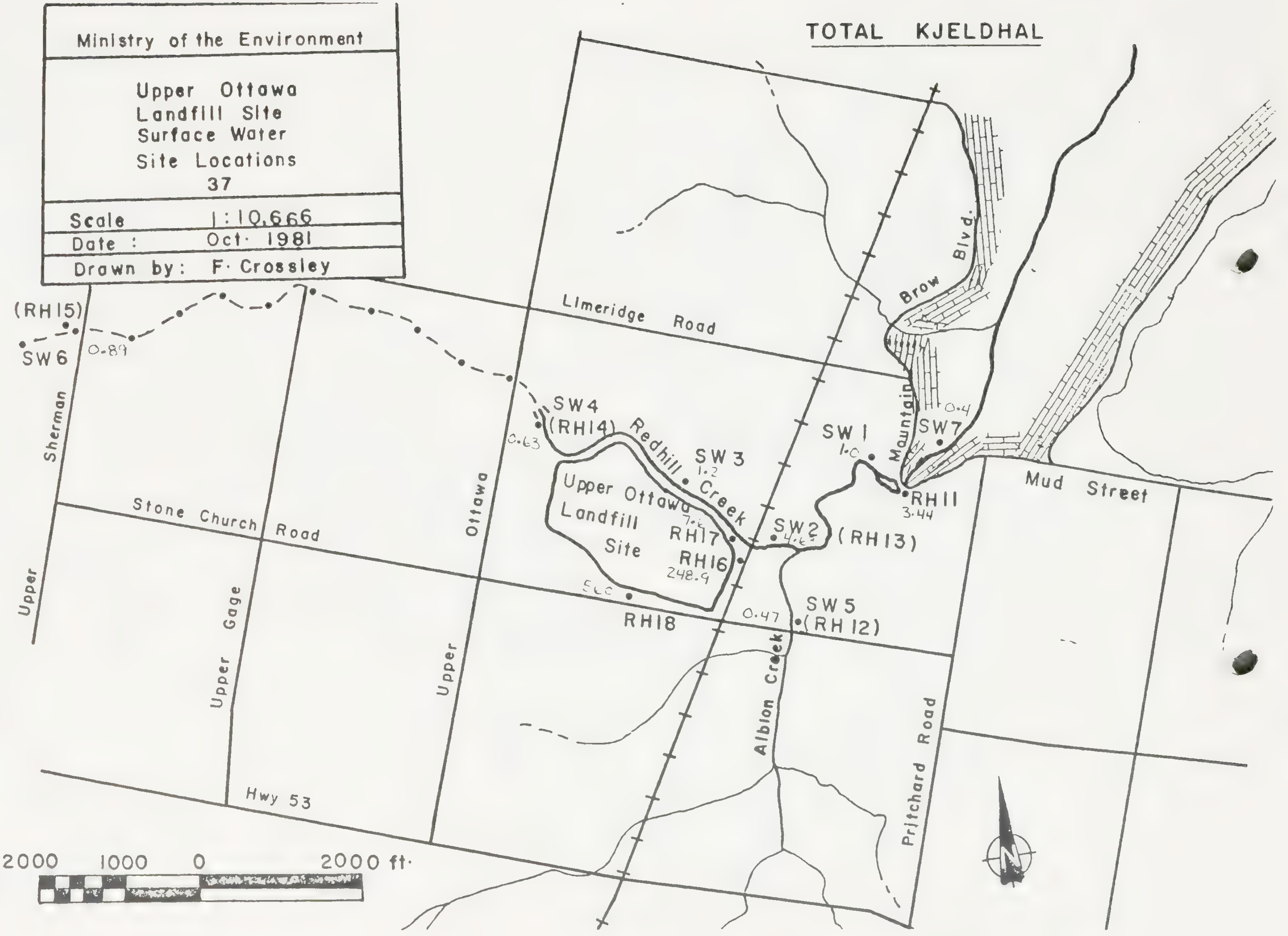
Ministry of the Environment

Upper Ottawa
Landfill Site
Surface Water
Site Locations
36

Scale 1:10,666
Date : Oct. 1981
Drawn by: F. Crossley

Figure # 36

TOTAL KJELDHAL



Ministry of the Environment

Upper Ottawa
Landfill Site
Surface Water
Site Locations
37

Scale 1:10,666
Date : Oct. 1981
Drawn by: F. Crossley

Figure # 37

NITRITE

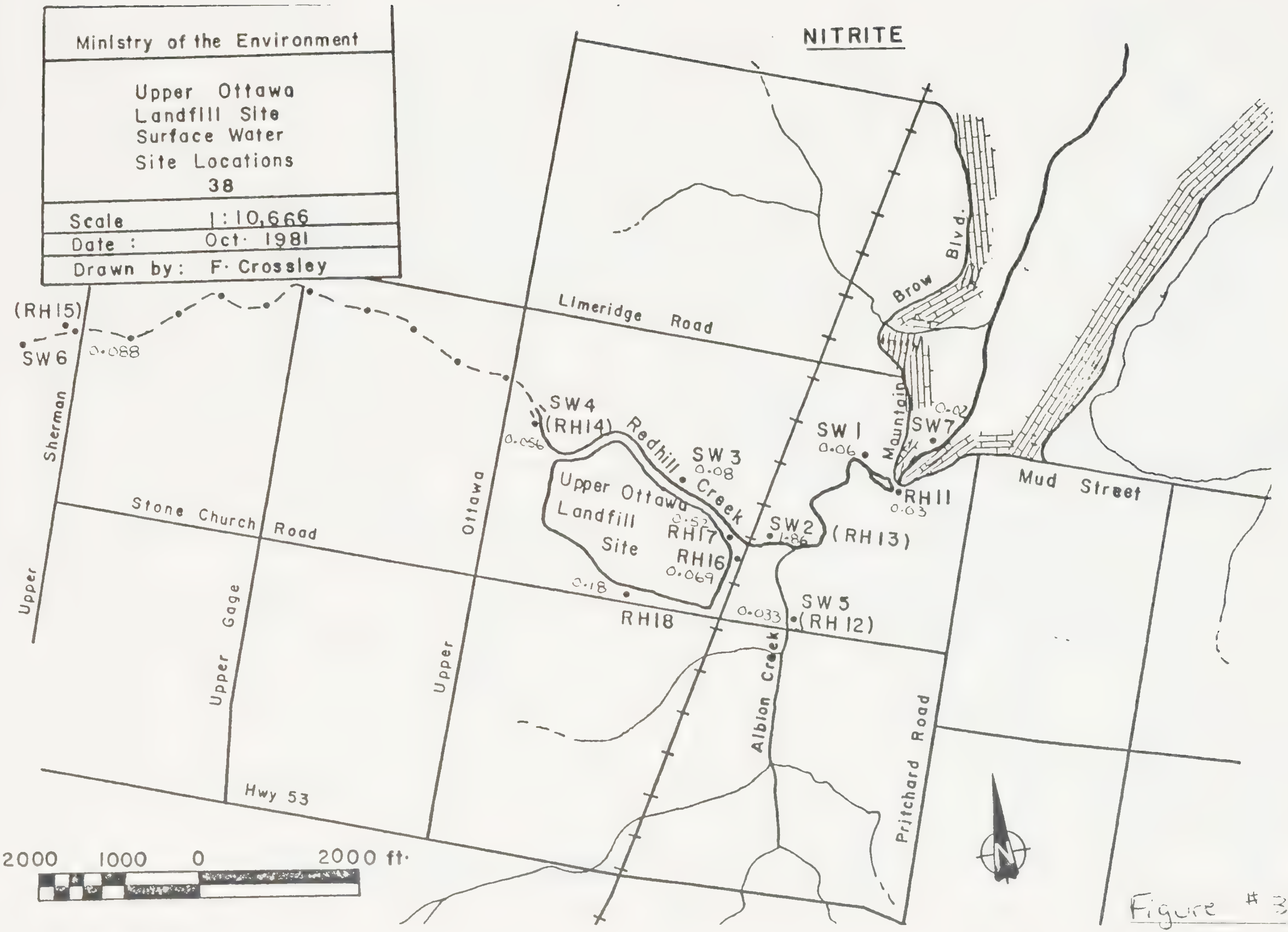
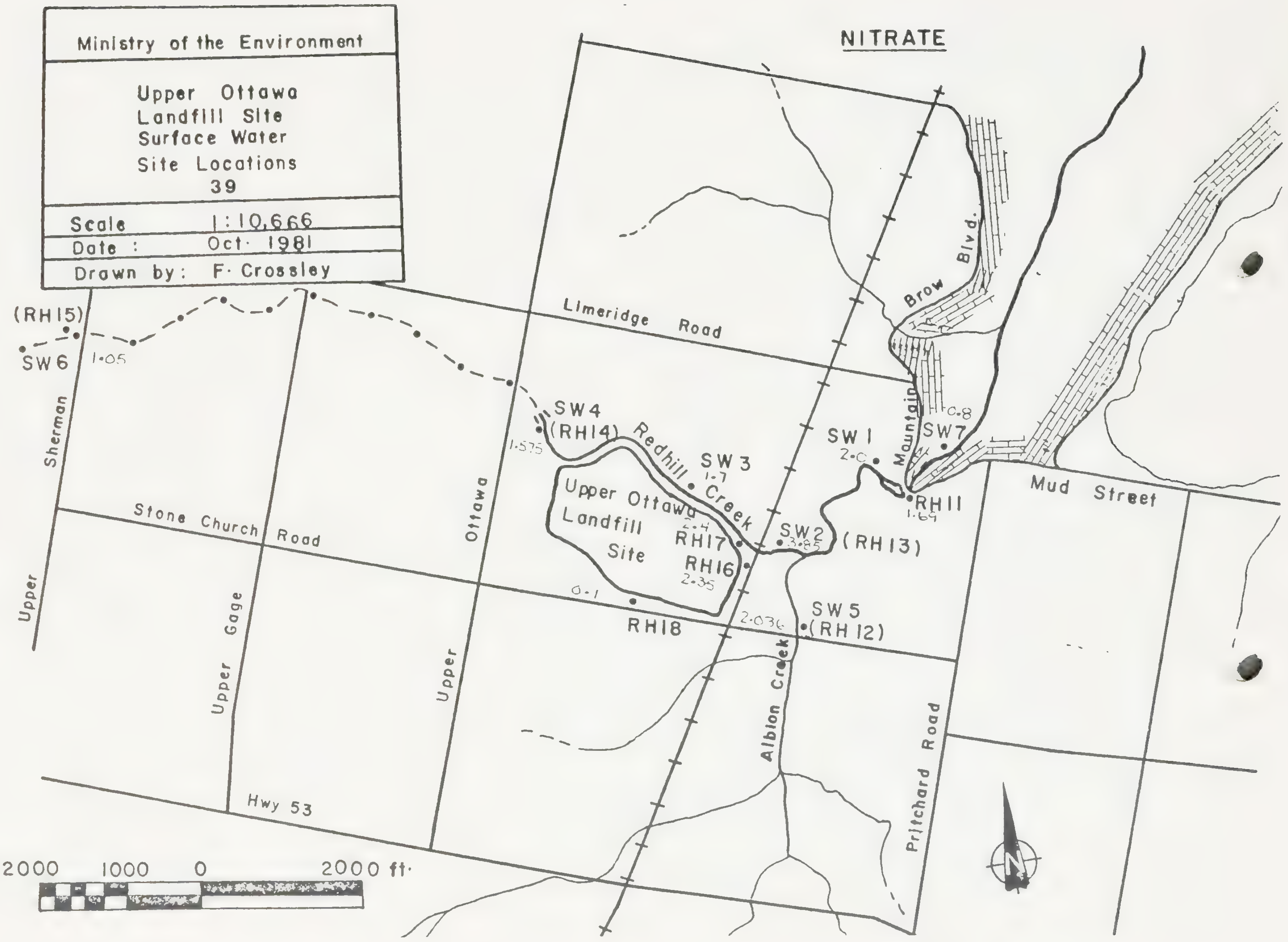


Figure # 38

NITRATE

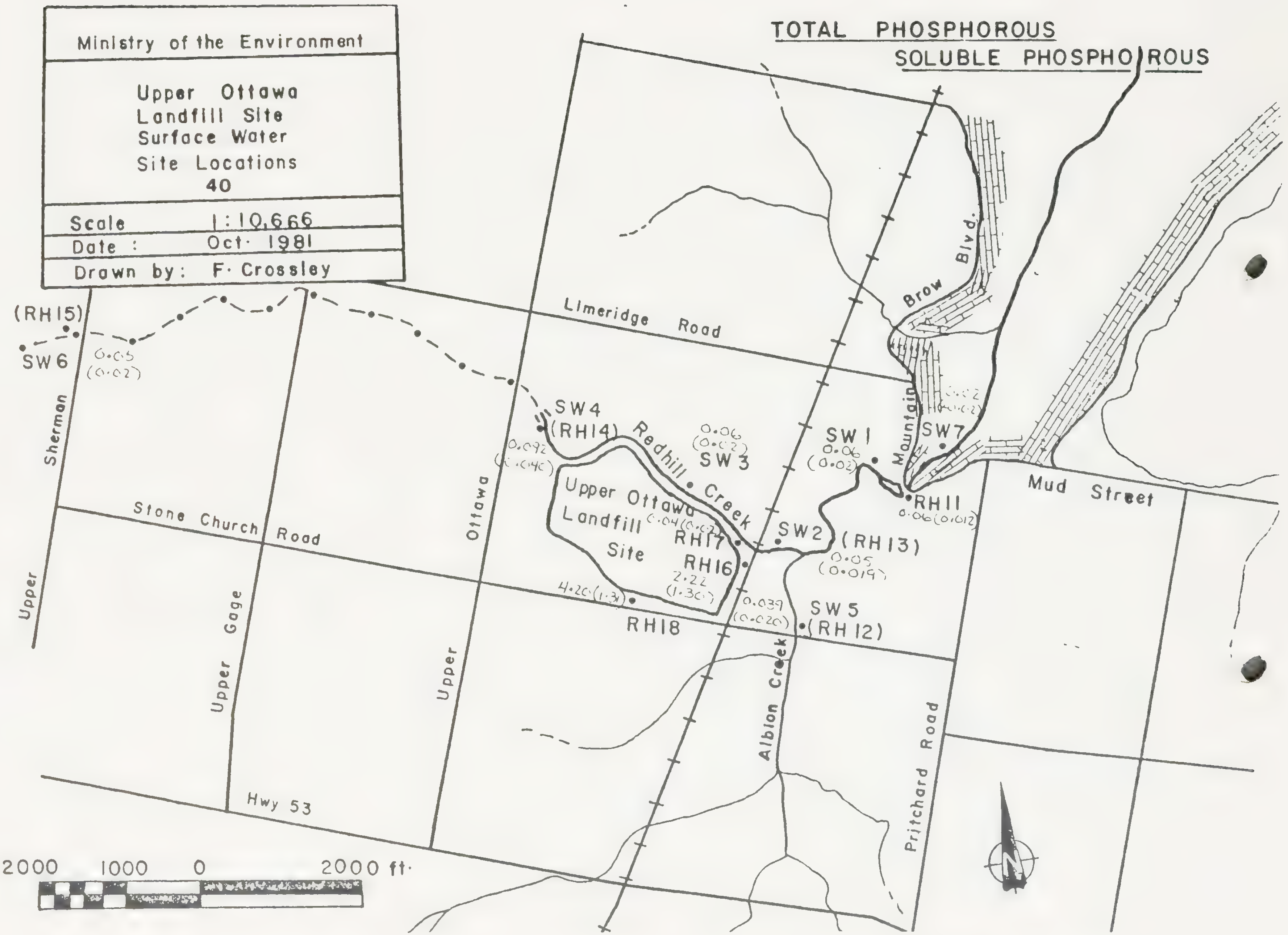


Ministry of the Environment

Upper Ottawa
Landfill Site
Surface Water
Site Locations
39

Scale 1:10,666
Date : Oct. 1981
Drawn by: F. Crossley

Figure # 39



TOTAL PHOSPHOROUS
SOLUBLE PHOSPHOROUS

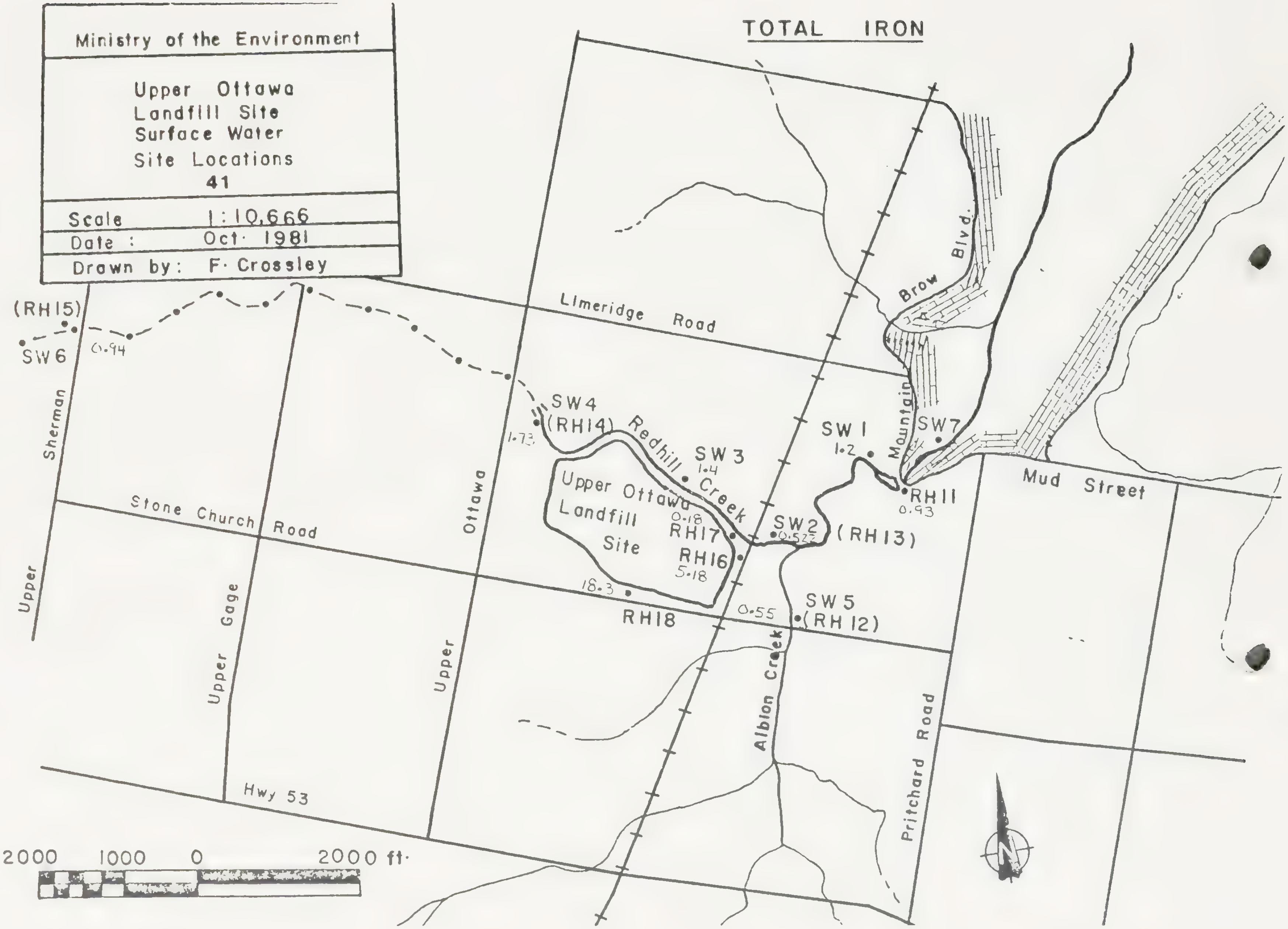
Ministry of the Environment

Upper Ottawa
Landfill Site
Surface Water
Site Locations
40

Scale 1:10,666
Date : Oct. 1981
Drawn by: F. Crossley

Figure # 4C

TOTAL IRON

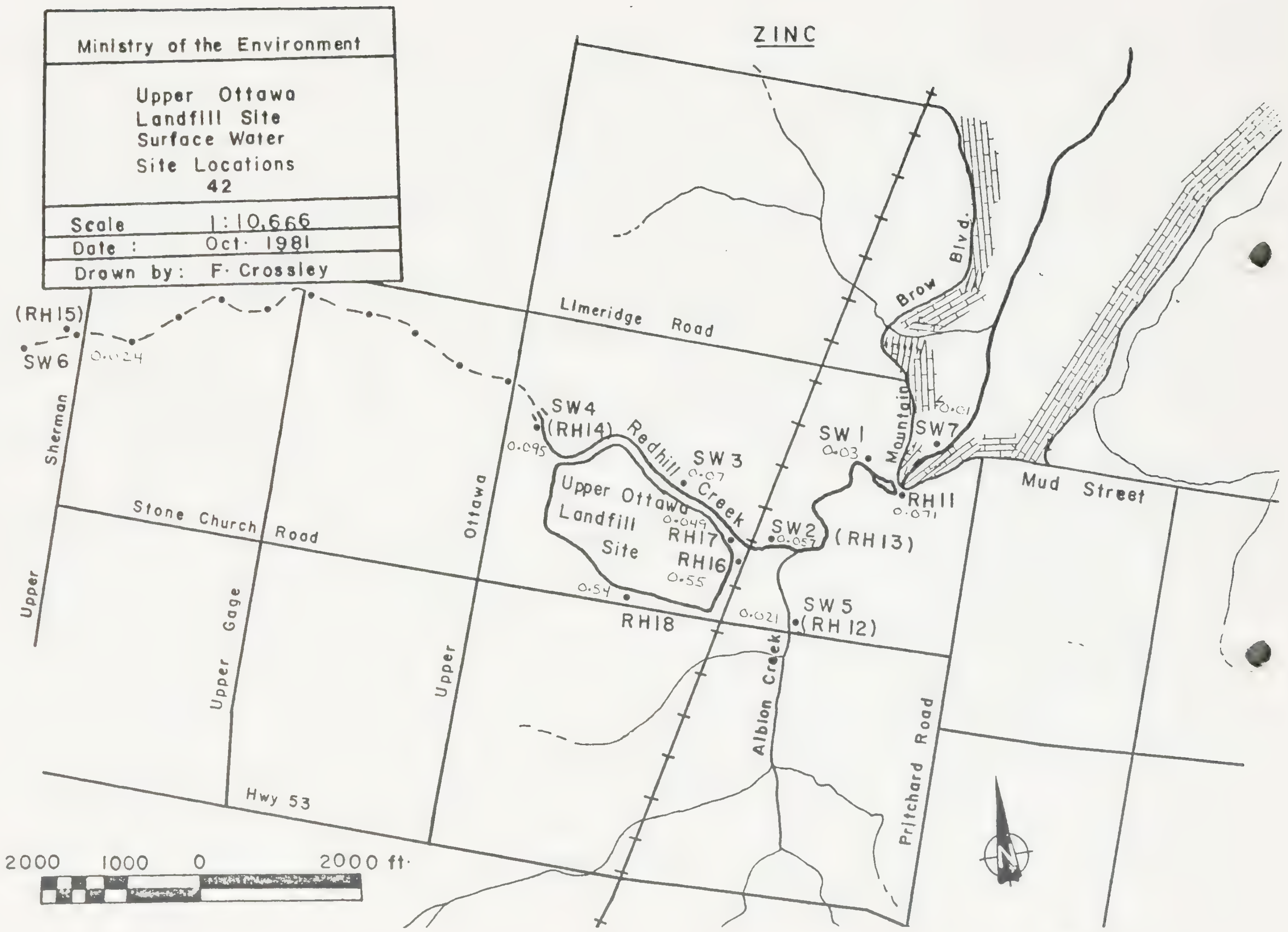


Ministry of the Environment

Upper Ottawa
Landfill Site
Surface Water
Site Locations
41

Scale 1:10,666
Date : Oct· 1981
Drawn by: F· Crossley

Figure #41

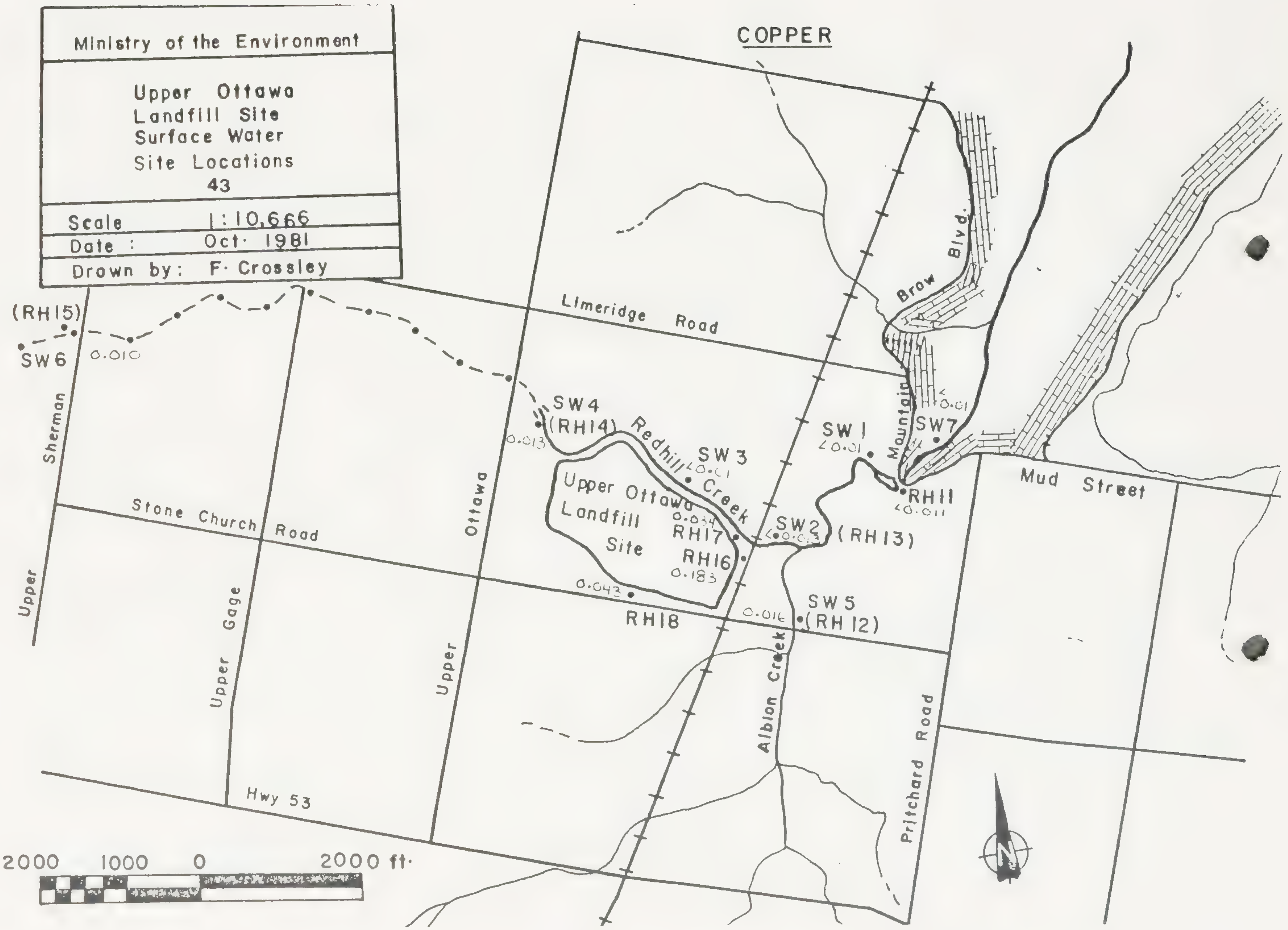


Ministry of the Environment

Upper Ottawa
Landfill Site
Surface Water
Site Locations
42

Scale 1:10,666
Date : Oct. 1981
Drawn by: F. Crossley

Figure #43

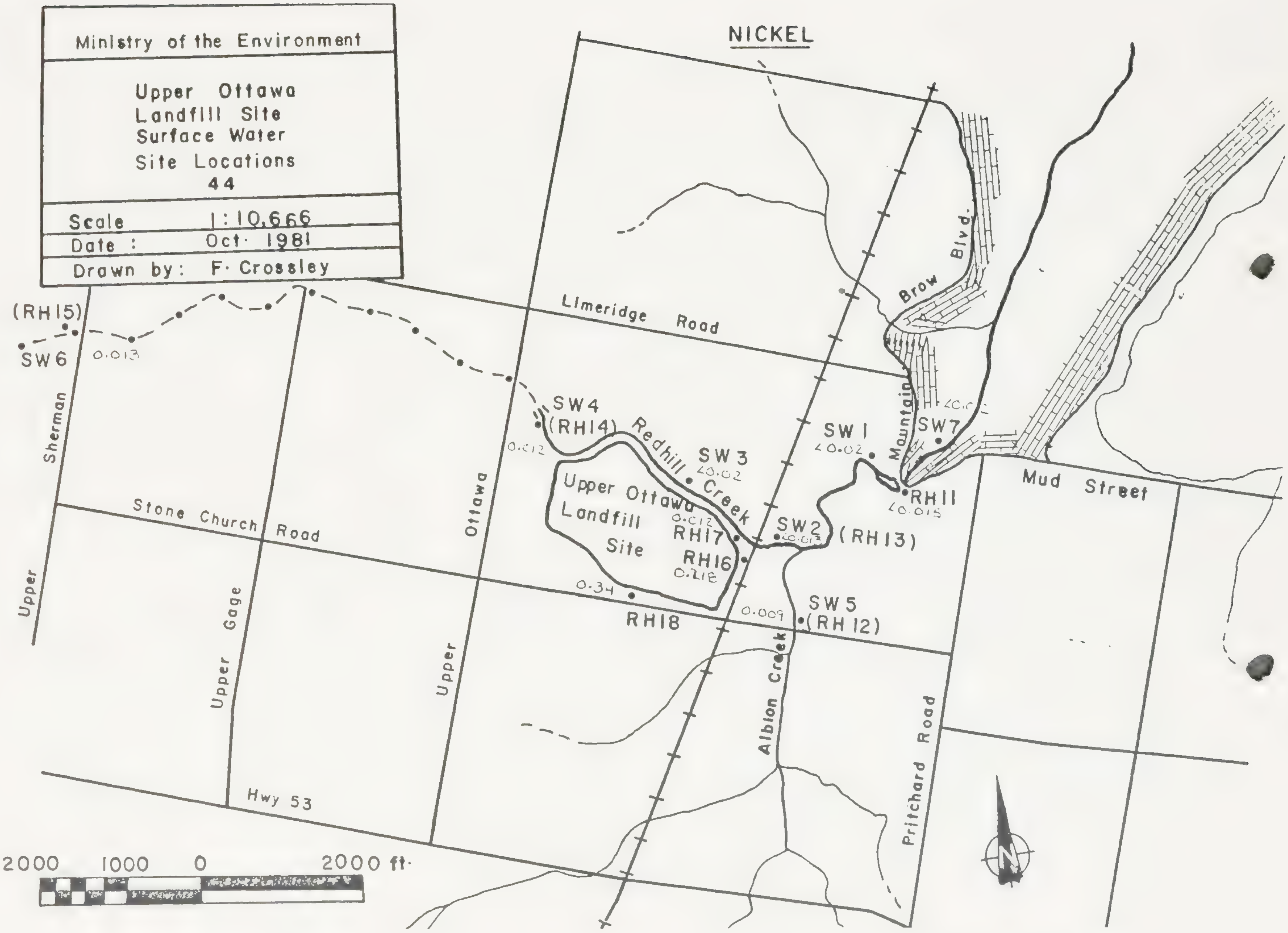


Ministry of the Environment

Upper Ottawa
Landfill Site
Surface Water
Site Locations
43

Scale 1:10,666
Date : Oct· 1981
Drawn by: F· Crossley

Figure #43

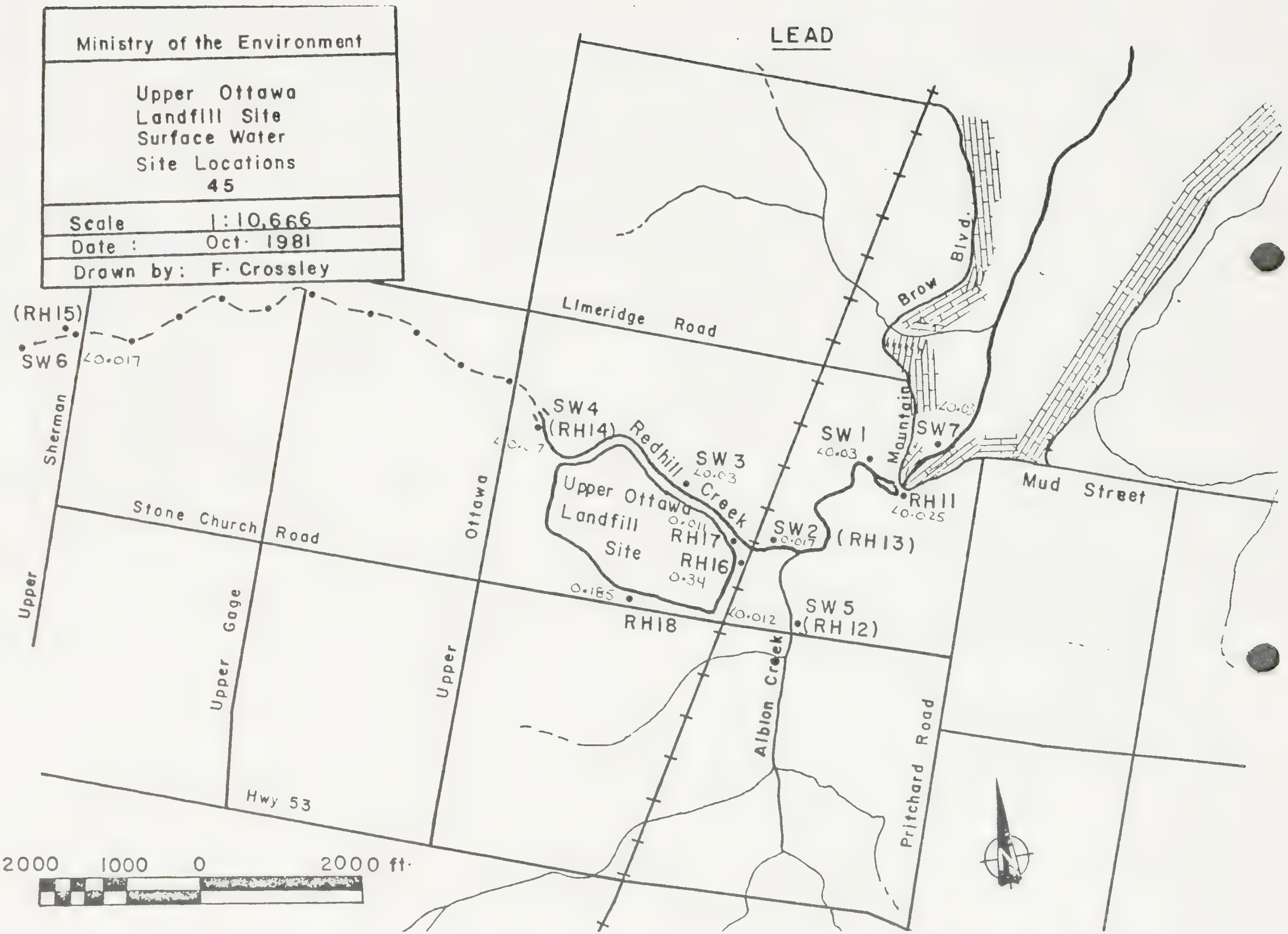


Ministry of the Environment

Upper Ottawa
Landfill Site
Surface Water
Site Locations
44

Scale	1:10,666
Date :	Oct. 1981
Drawn by:	F. Crossley

Figure #44



Ministry of the Environment

Upper Ottawa
Landfill Site
Surface Water
Site Locations
45

Scale 1:10,666
Date : Oct. 1981
Drawn by: F. Crossley

Figure #45

CADMIUM

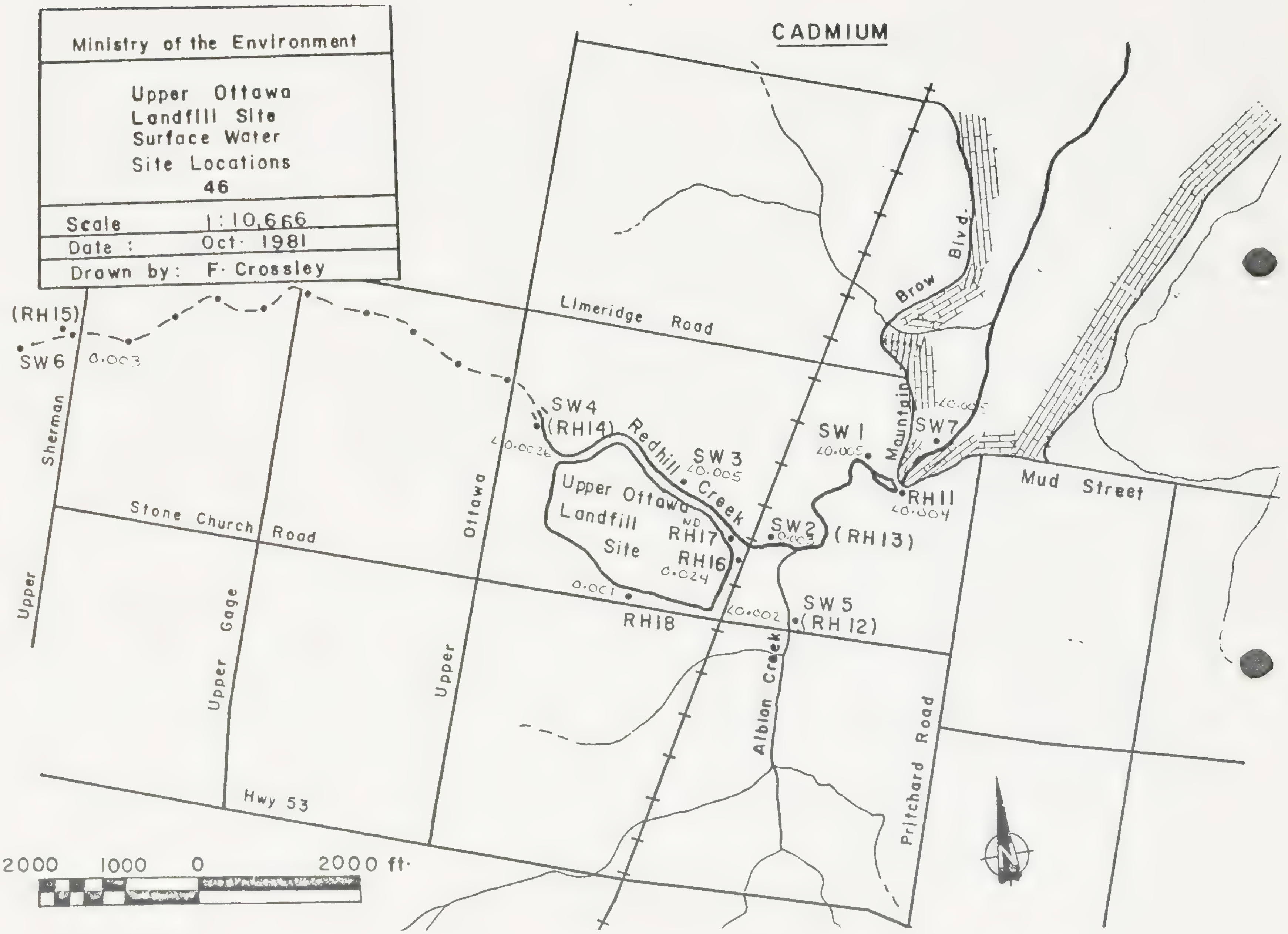
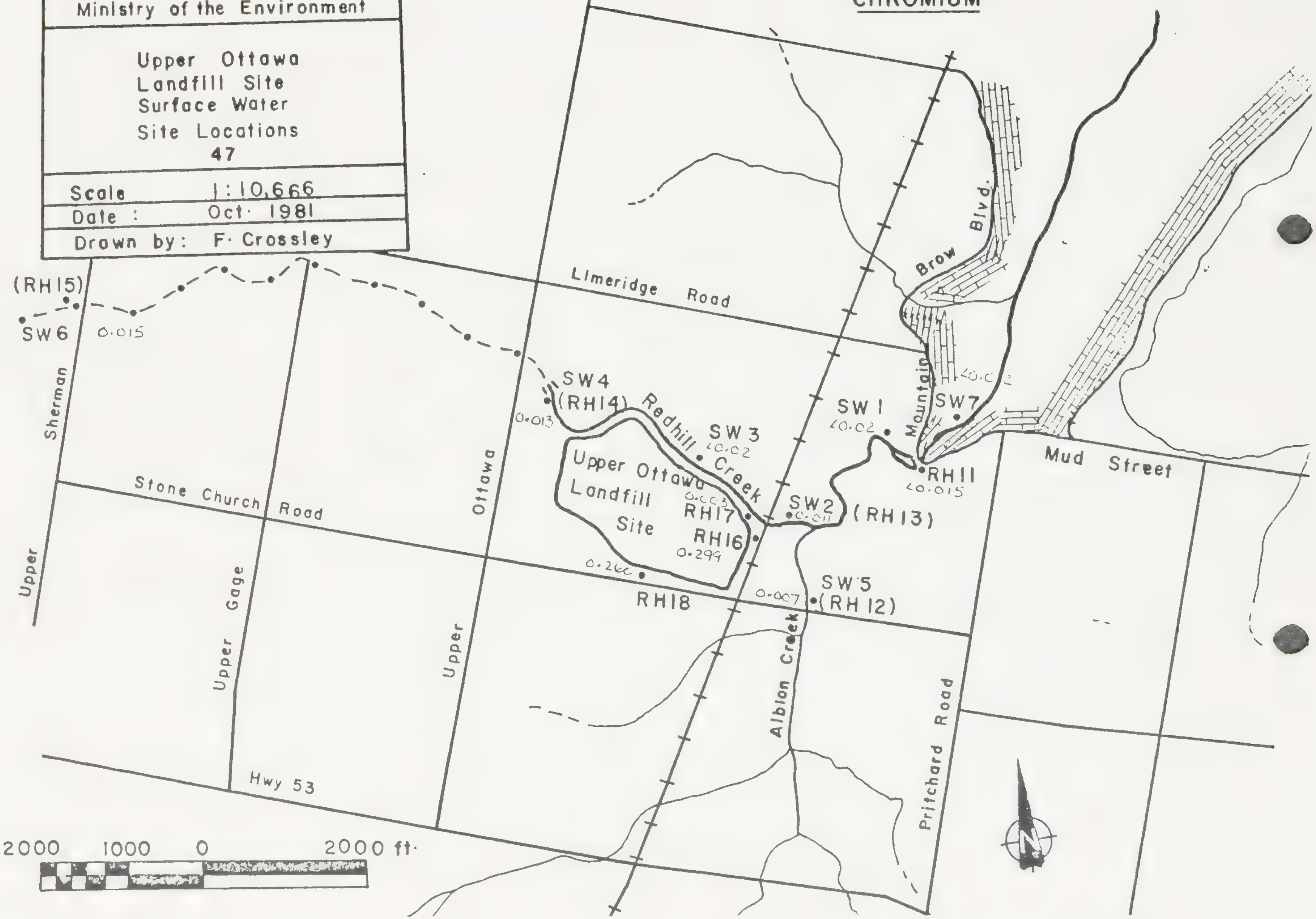


Figure #46

CHROMIUM



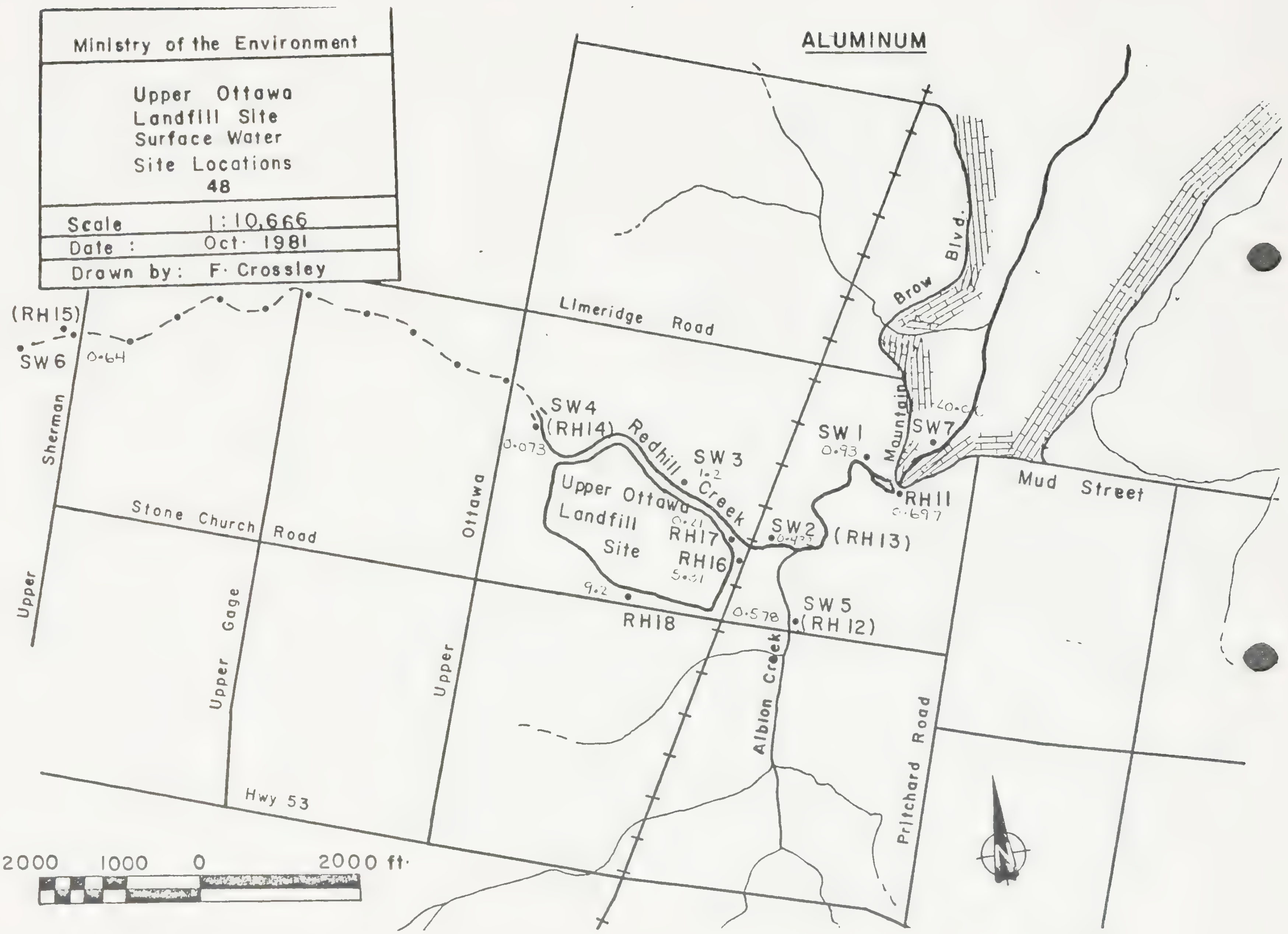
Ministry of the Environment

Upper Ottawa
Landfill Site
Surface Water
Site Locations
47

Scale	1:10,666
Date :	Oct. 1981
Drawn by:	F. Crossley

Figure #47

ALUMINUM



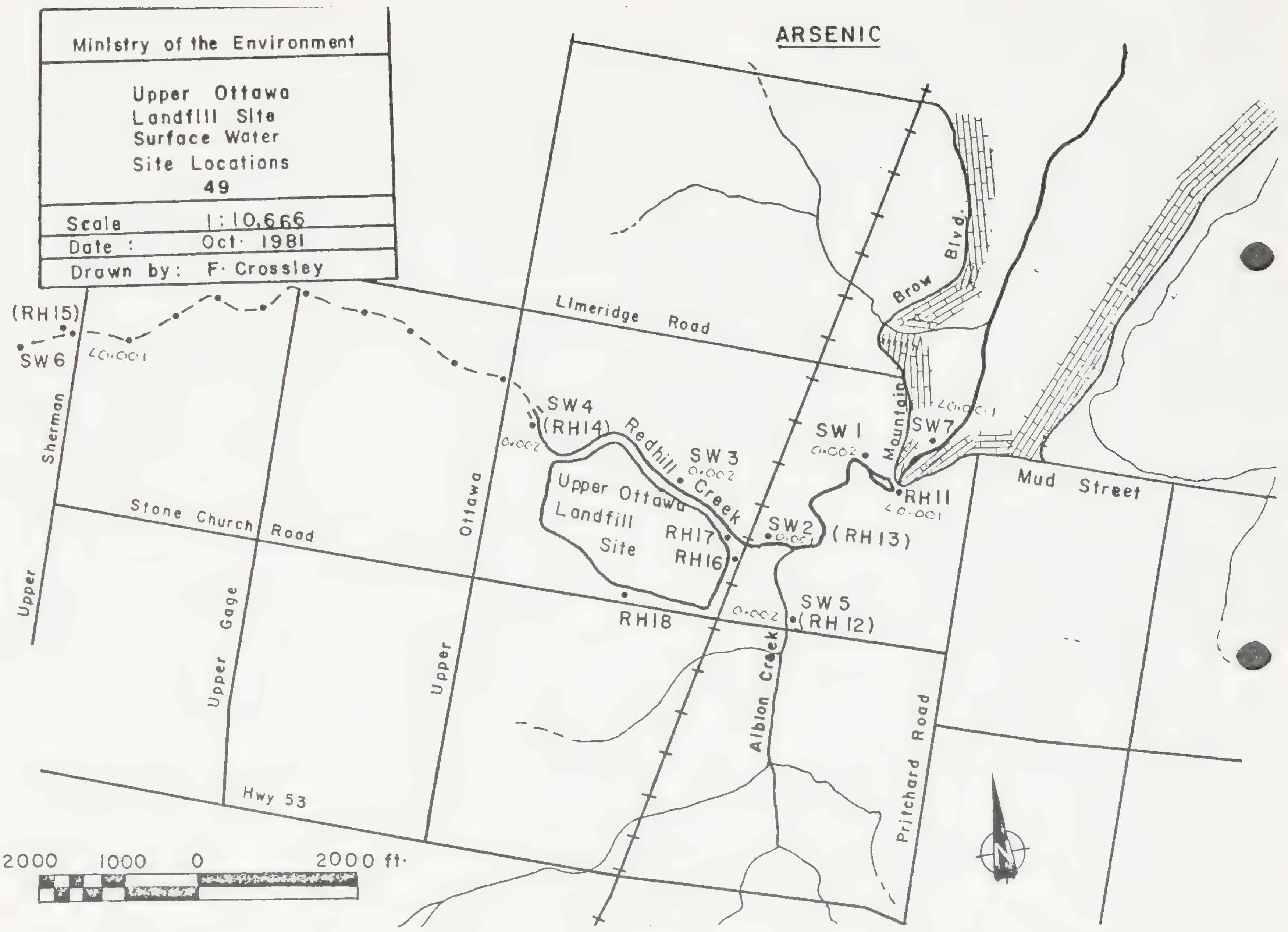
Ministry of the Environment

Upper Ottawa
Landfill Site
Surface Water
Site Locations
48

Scale 1:10,666
Date : Oct. 1981
Drawn by: F. Crossley

Figure #48

ARSENIC



Ministry of the Environment

Upper Ottawa
Landfill Site
Surface Water
Site Locations
49

Scale 1:10,666
Date : Oct. 1981
Drawn by: F. Crossley

Figure #49

MANGANESE

Ministry of the Environment

Upper Ottawa
Landfill Site
Surface Water
Site Locations
50

Scale 1:10,666
Date : Oct. 1981
Drawn by: F. Crossley

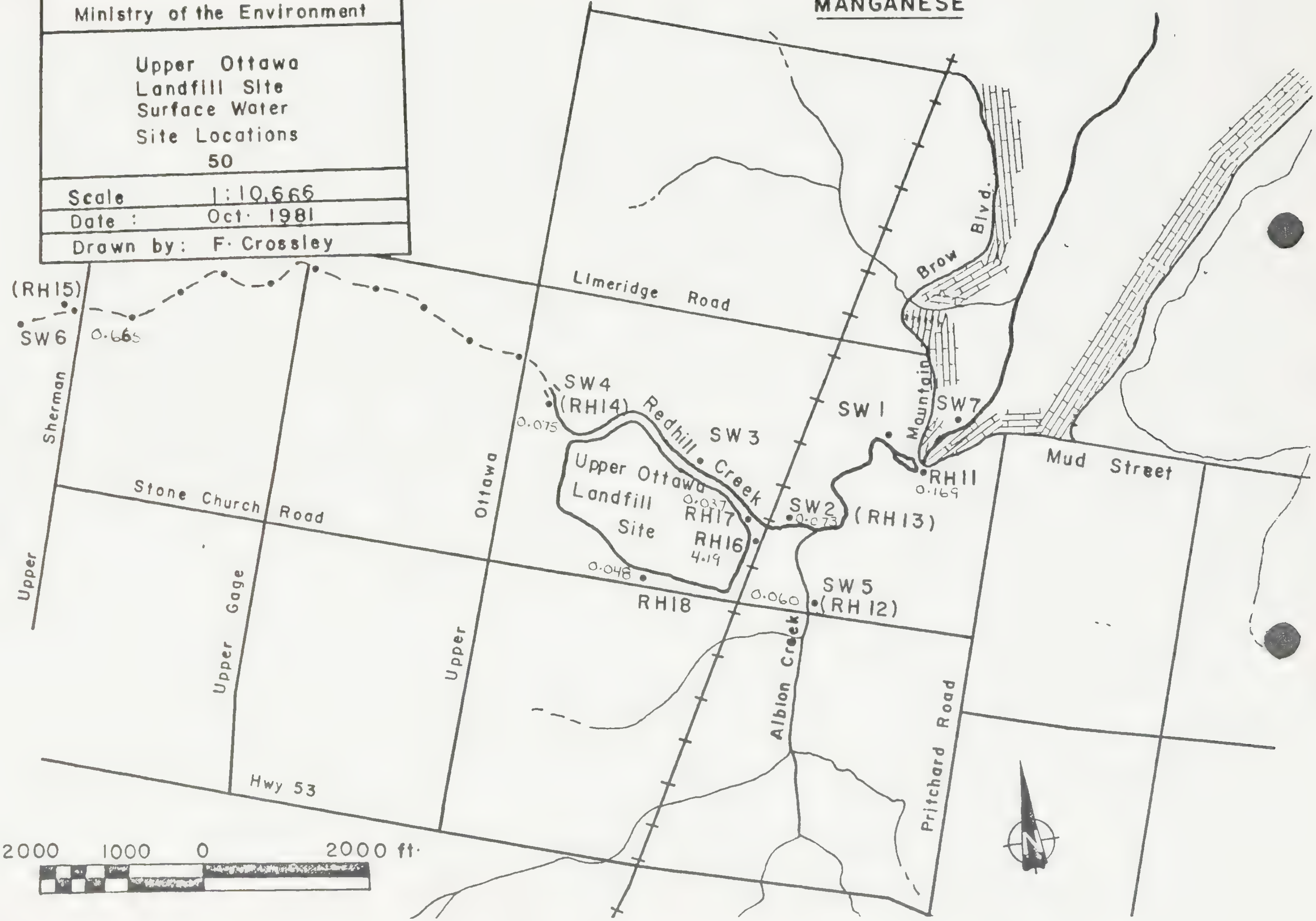
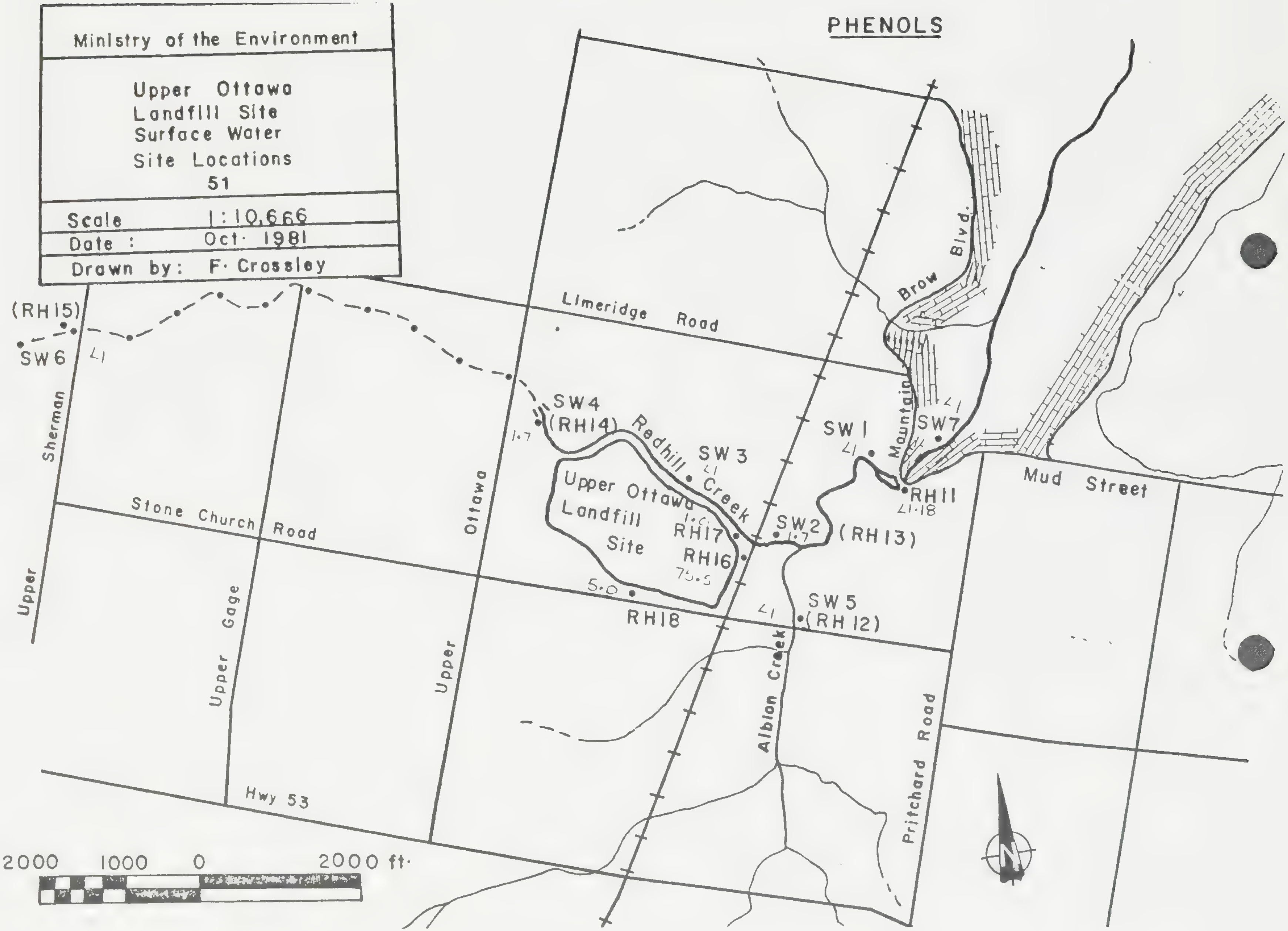


Figure H 50

PHENOLS



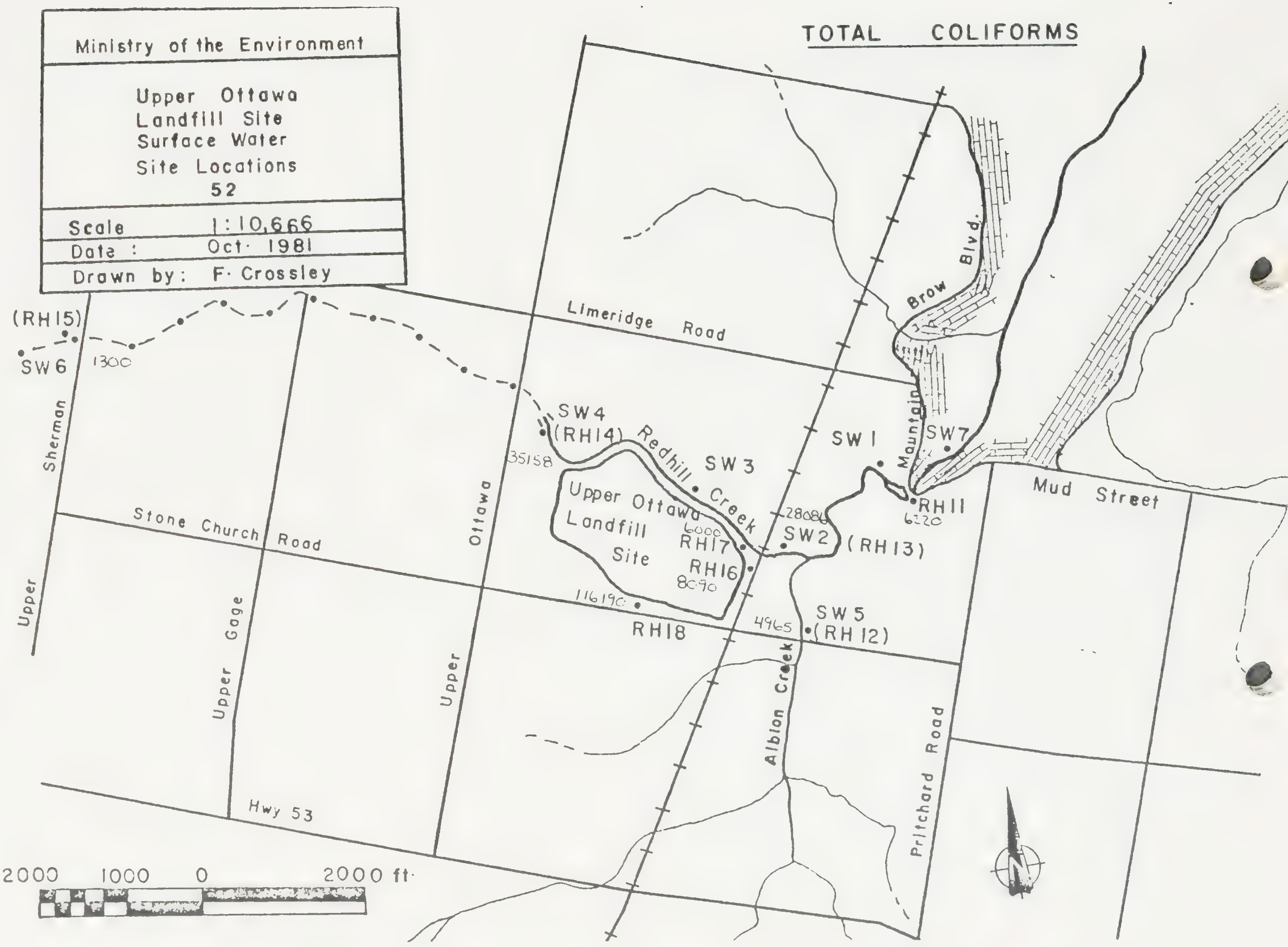
Ministry of the Environment

Upper Ottawa
Landfill Site
Surface Water
Site Locations
51

Scale 1:10,666
Date : Oct. 1981
Drawn by: F. Crossley

Figure # 51

TOTAL COLIFORMS



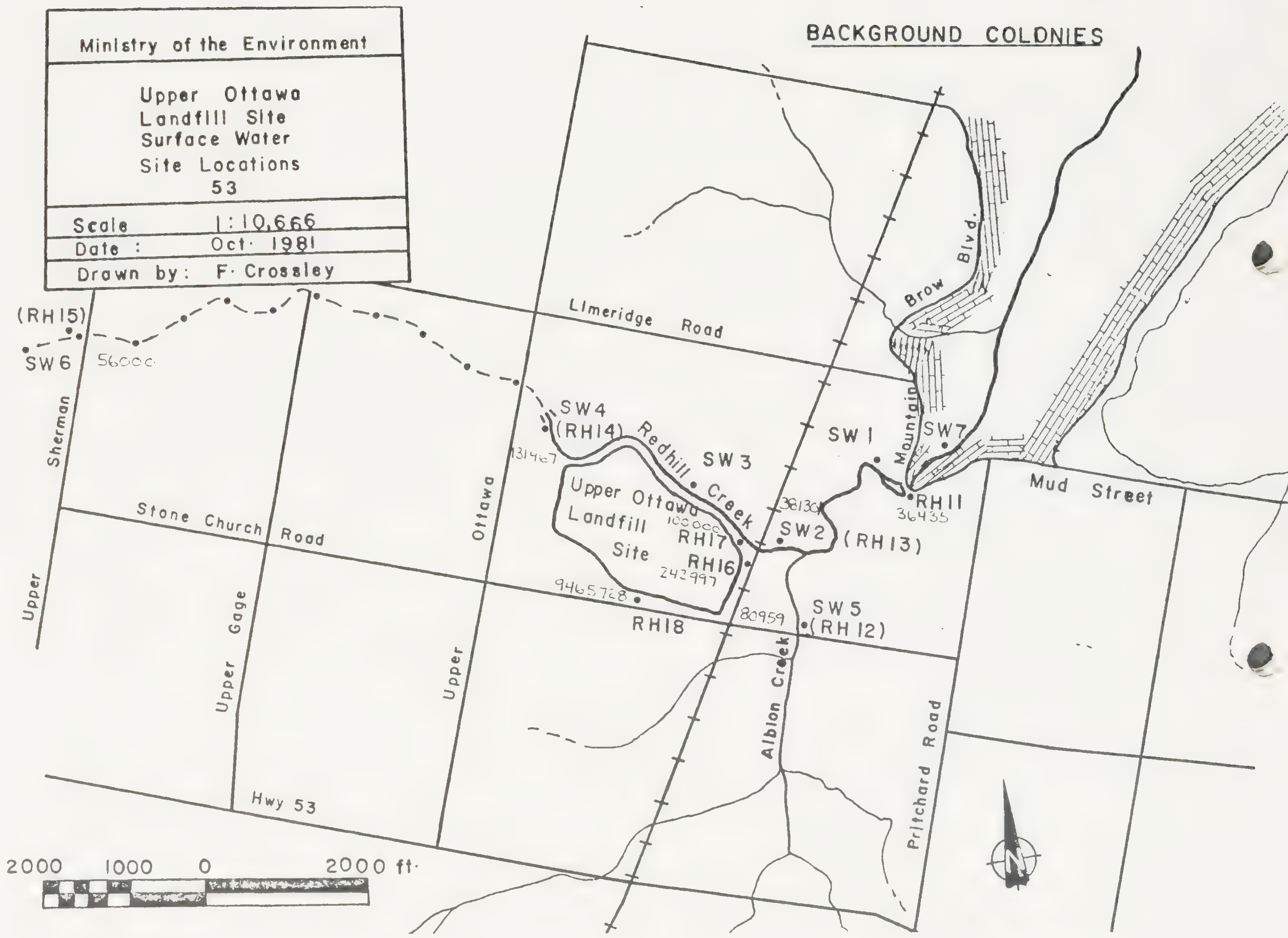
Ministry of the Environment

Upper Ottawa
Landfill Site
Surface Water
Site Locations
52

Scale 1:10,666
Date : Oct. 1981
Drawn by: F. Crossley

Figure [illegible]

BACKGROUND COLONIES



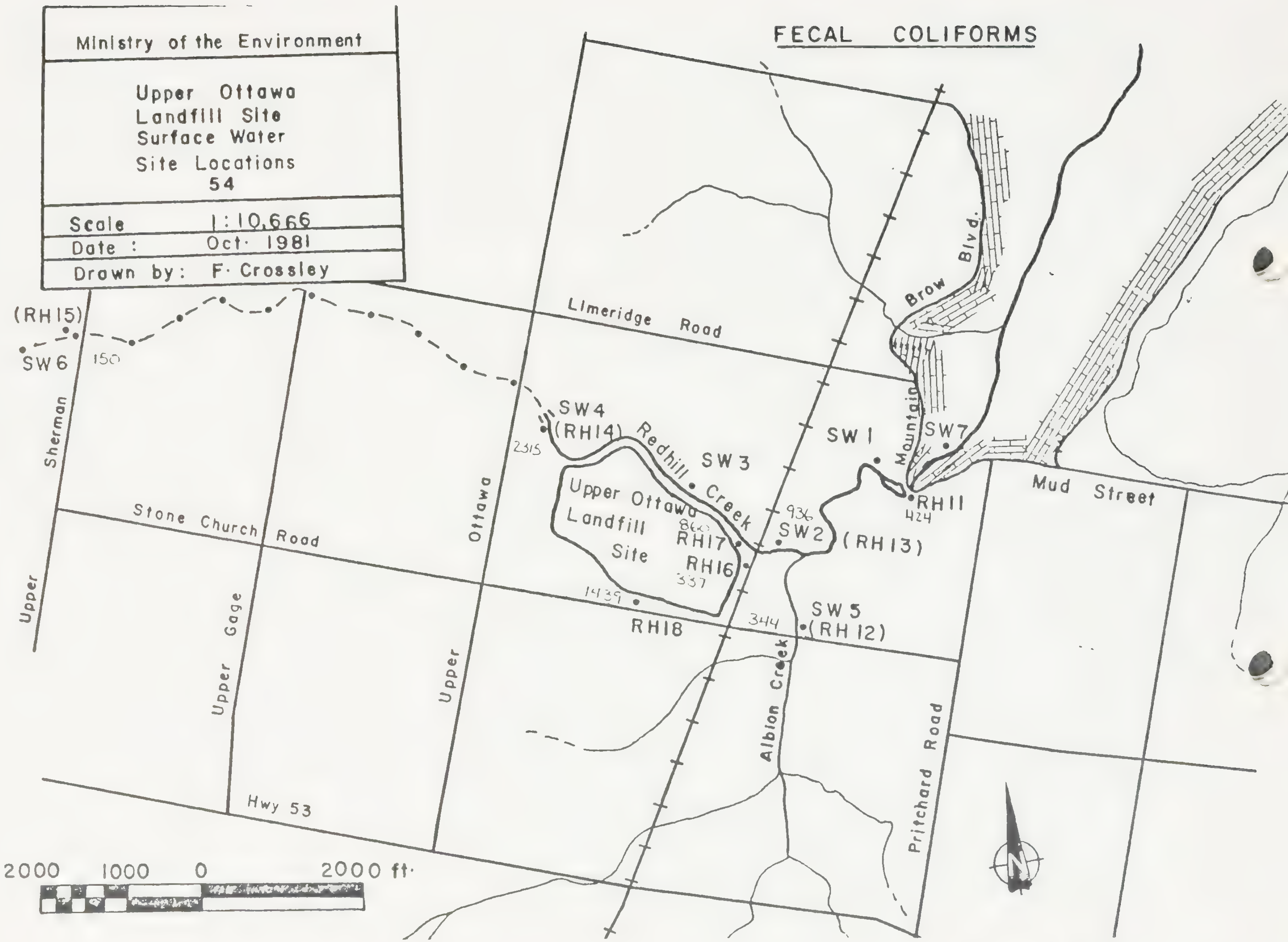
Ministry of the Environment

Upper Ottawa
Landfill Site
Surface Water
Site Locations
53

Scale	1:10,666
Date :	Oct. 1981
Drawn by:	F. Crossley

Figure #33

FECAL COLIFORMS

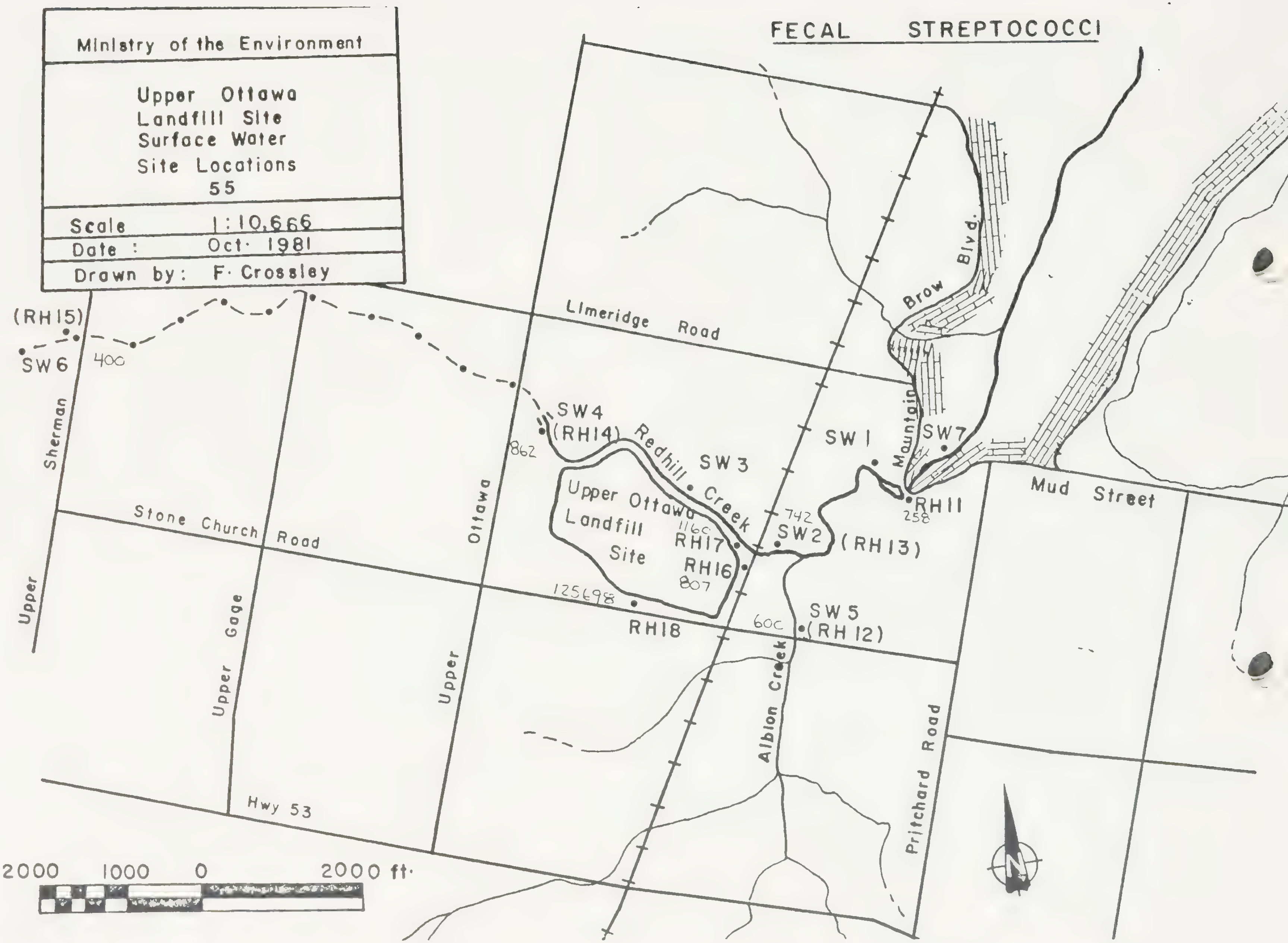


Ministry of the Environment

Upper Ottawa
Landfill Site
Surface Water
Site Locations
54

Scale 1:10,666
Date : Oct. 1981
Drawn by: F. Crossley

Figure #24



FECAL STREPTOCOCCI

Ministry of the Environment

Upper Ottawa
Landfill Site
Surface Water
Site Locations
55

Scale 1:10,666
Date : Oct. 1981
Drawn by: F. Crossley

Figure 11.35

FECAL COLIFORM : FECAL STREPTOCOCCI RATIO

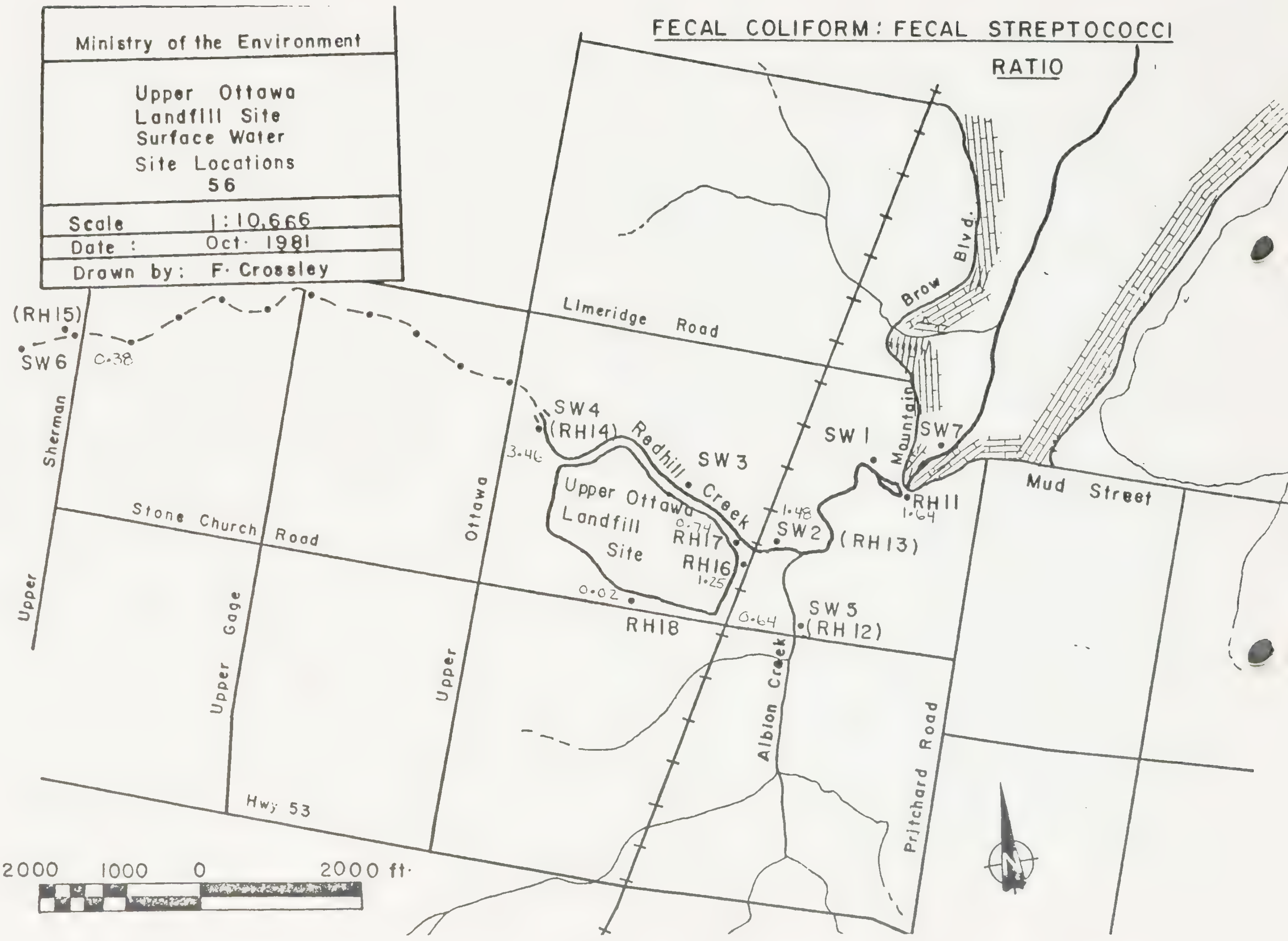


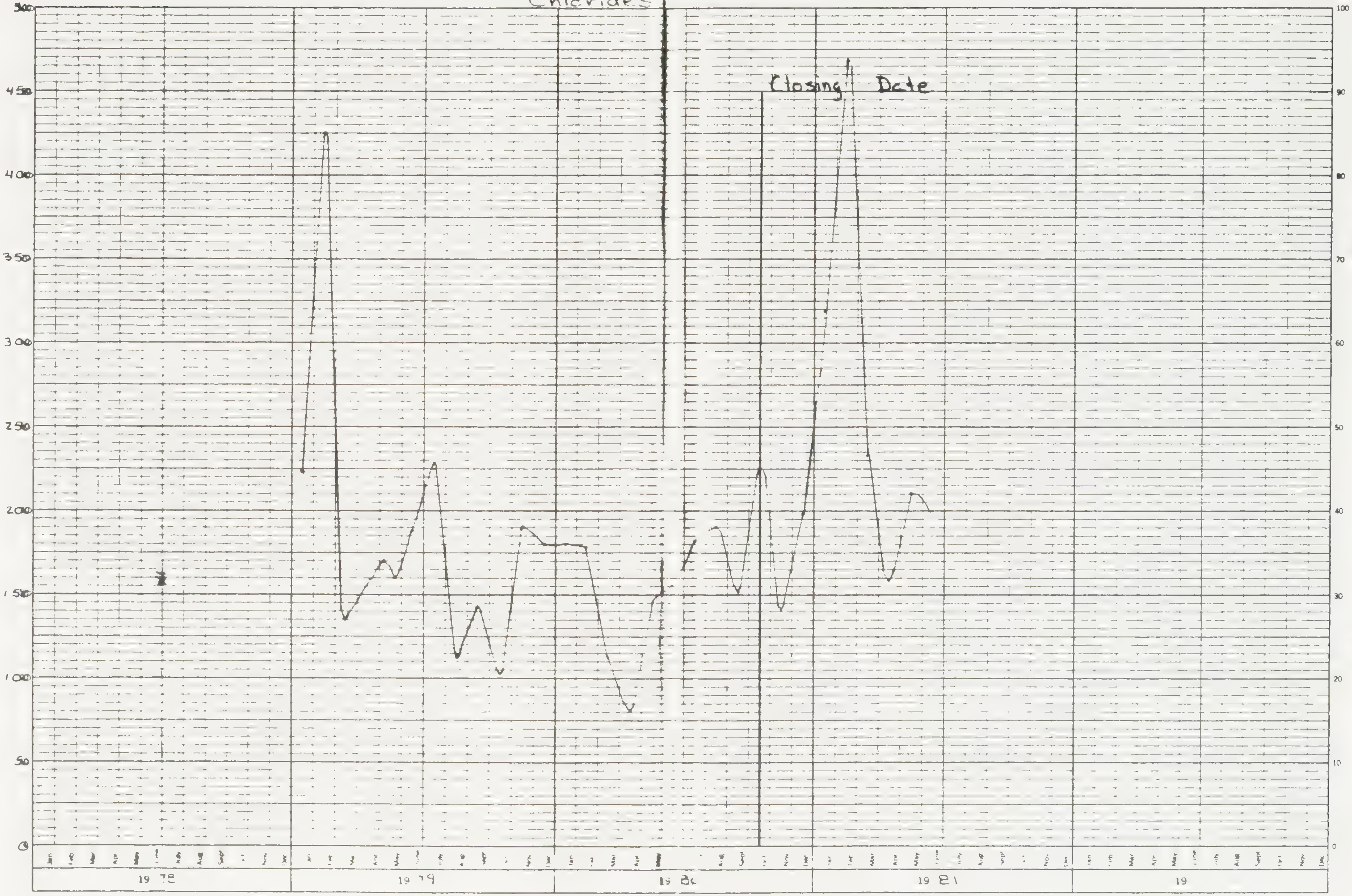
Figure # 56

APPENDIX II

81

Redhill Creek at Mount Albion Falls (RH11)

Chlorides



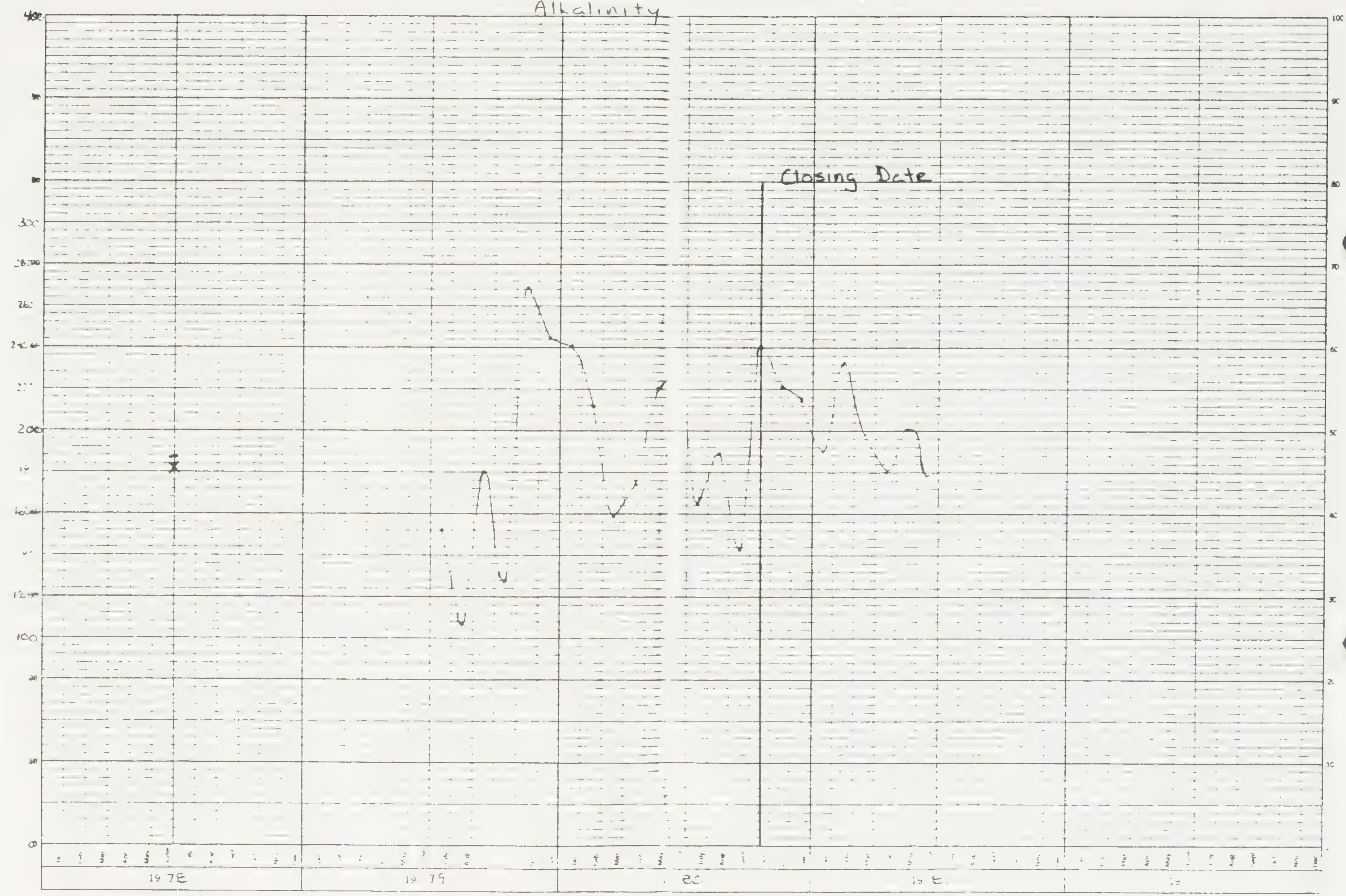
x̄ value only

K+E 5 YEARS BY MONTHS X 100 DIVISIONS
KEUFFEL & ESSER CO. MADE IN U.S.A.

47 3653

Redhill Creek at Mount Albion Falls (RH1)

Alkalinity



* mean value only

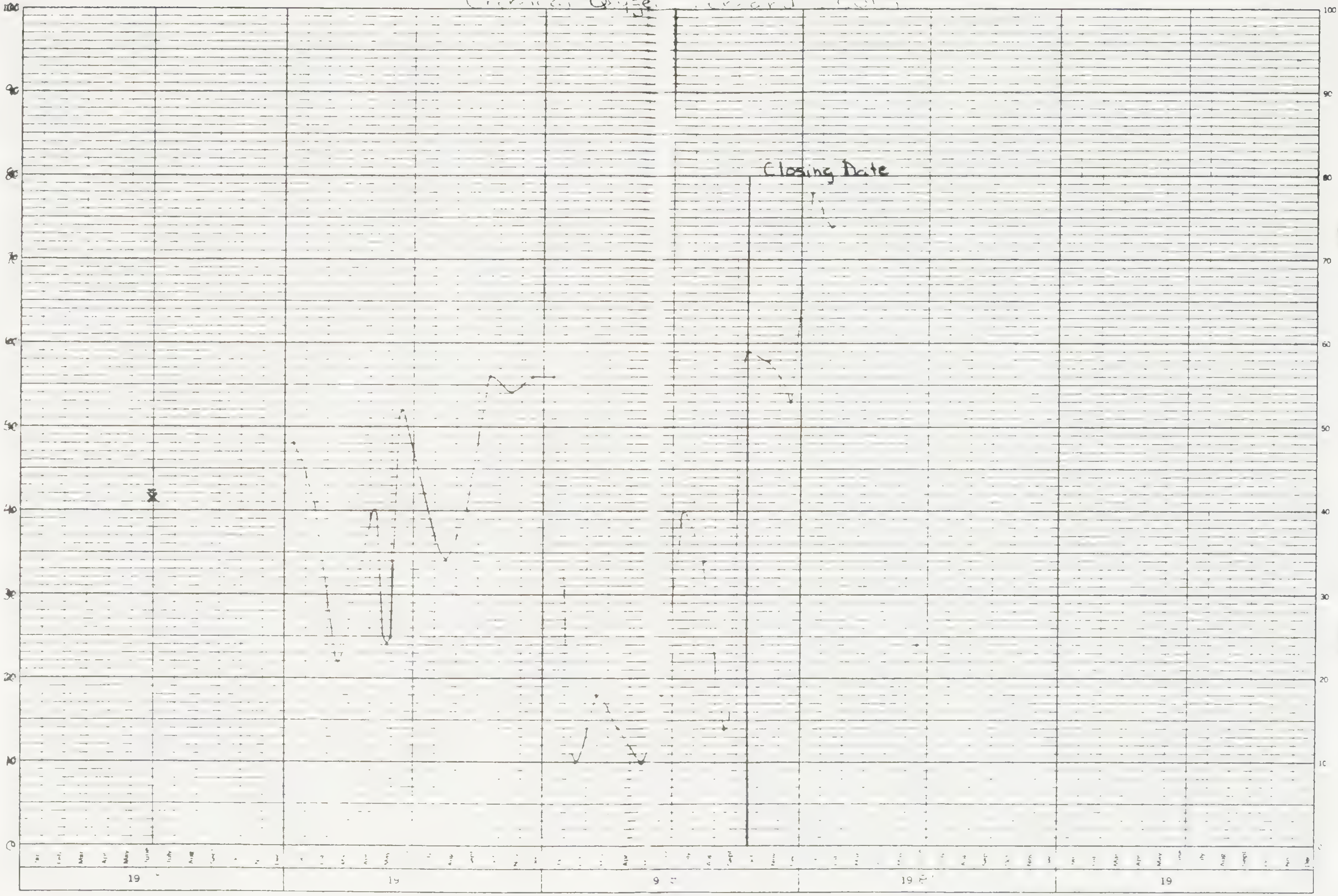
47 3653

K+E 5 YEARS BY MONTHS X 100 DIVISIONS
KEUFFEL & ESSER CO. MADE IN U.S.A.

63

Redhill Creek at Mount Albion Falls (FHL)

Chronical Gauge Record (CG)



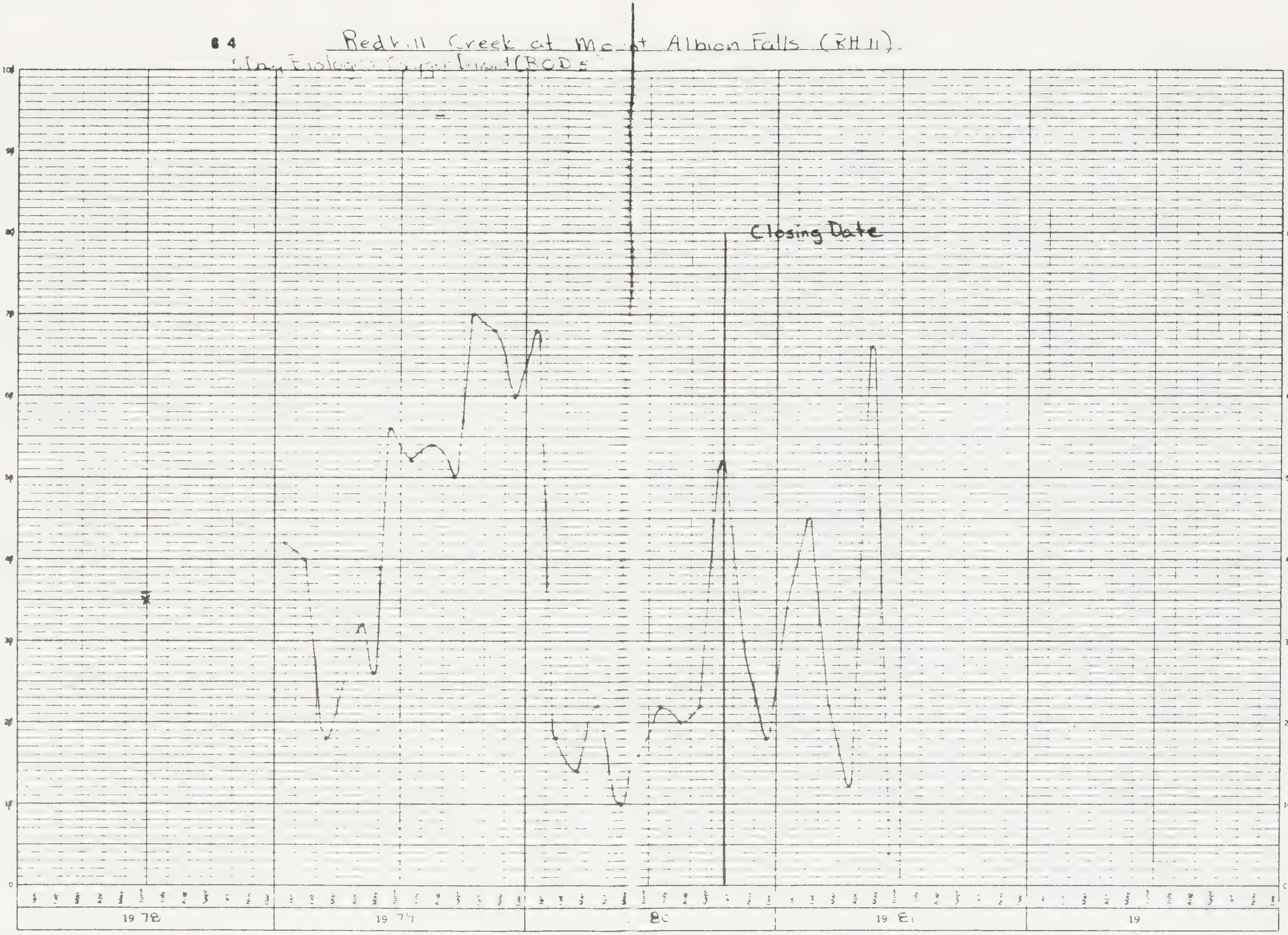
K+E 5 YEARS BY MONTHS X 100 DIVISIONS
KEUFFEL & ESSER CO. MADE IN U.S.A.

47 3653

84

Redhill Creek at Mount Albion Falls (RH11)

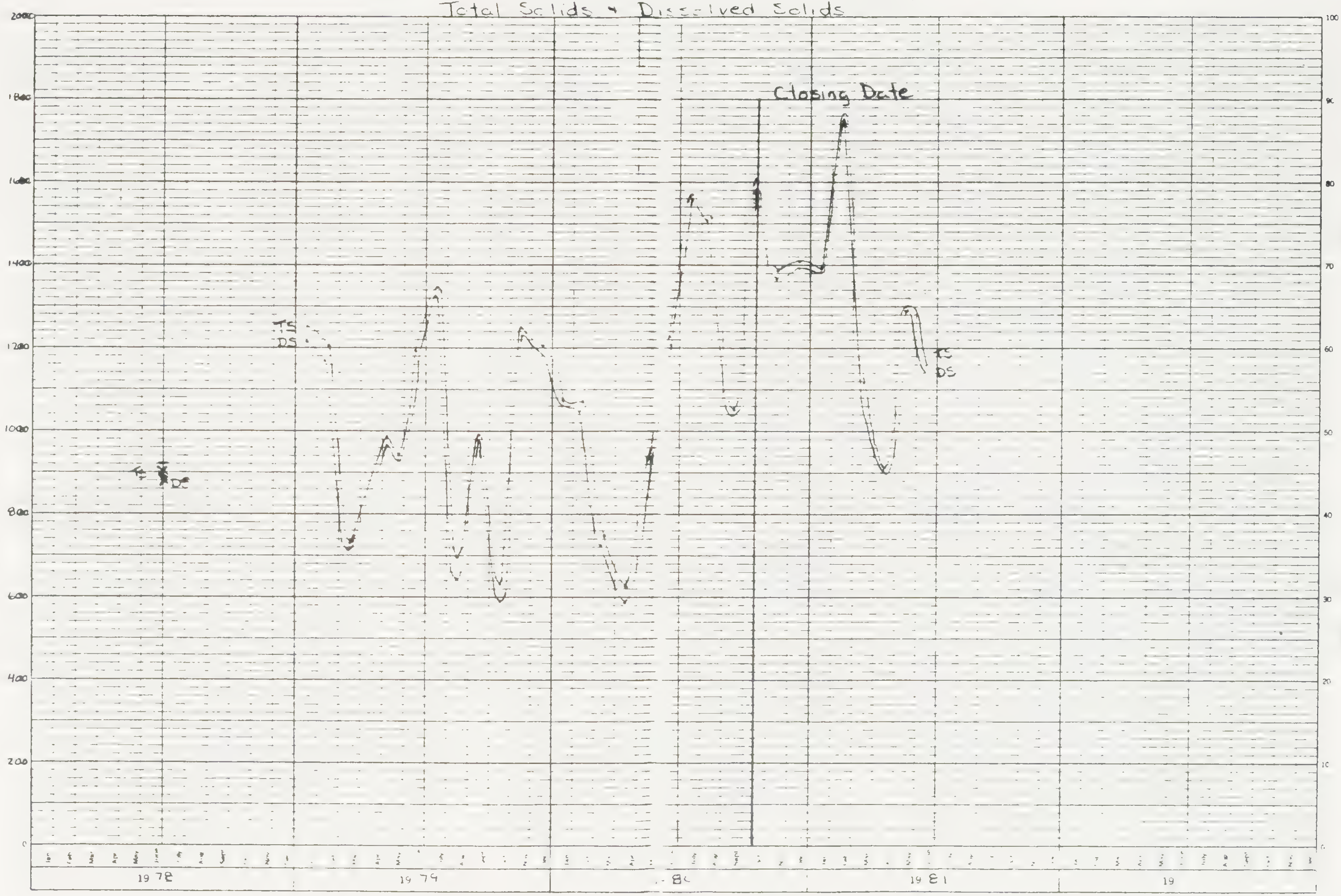
5 Day Biological Oxygen Demand (BOD5)



x̄ value only

K+E 5 YEARS BY MONTHS X 100 DIVISIONS
KEUFFEL & ESSER CO. MADE IN U.S.A.
47 3653

Redhill Creek at Mount Albion Falls (RH11)
Total Solids + Dissolved Solids



x̄ mean values only

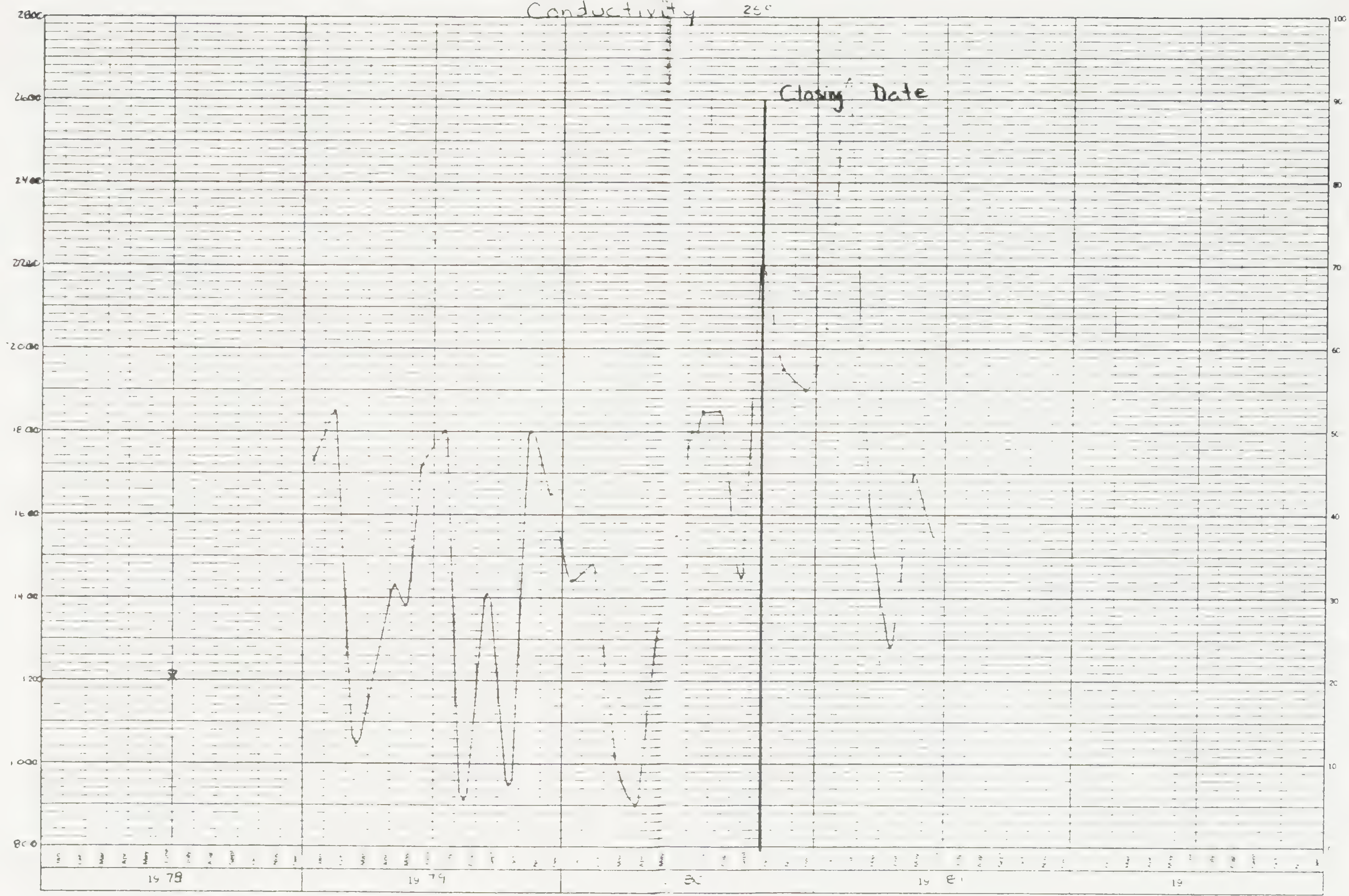
TS - Total Solids DS - Dissolved Solids

K+E 5 YEARS BY MONTHS X 100 DIVISIONS
KEUFFEL & ESSER CO. MADE IN U.S.A.
47 3653

6

Redhill Creek at Mount Albion Falls (BH11)

Conductivity 25°



x̄ value only

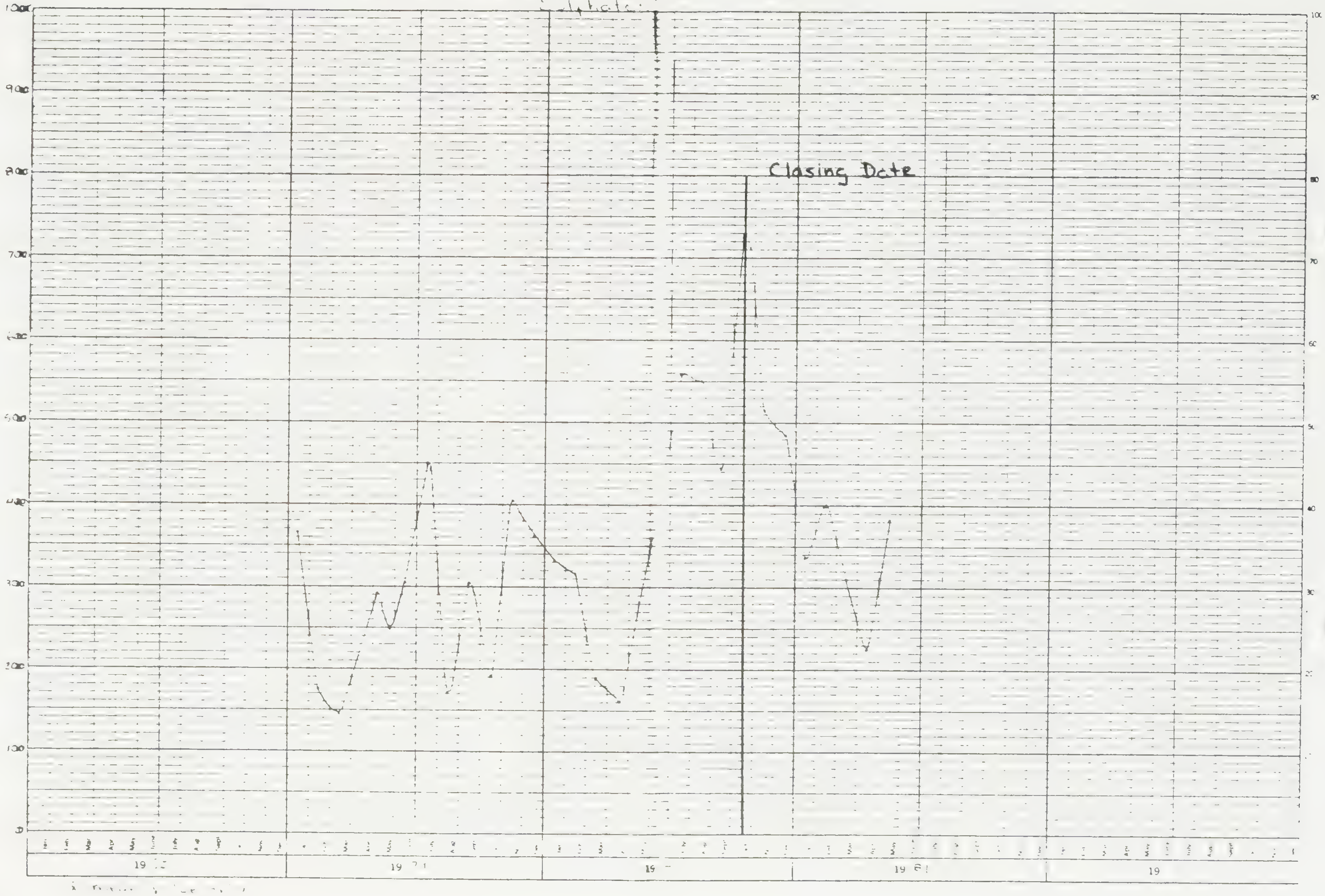
47 3653

K+E 5 YEARS BY MONTHS X 100 DIVISIONS
KEUFFEL & ESSER CO. MADE IN U.S.A.

6 7

Fedrill Creek at Mount Alber Falls (F.H11)

Sulphate:

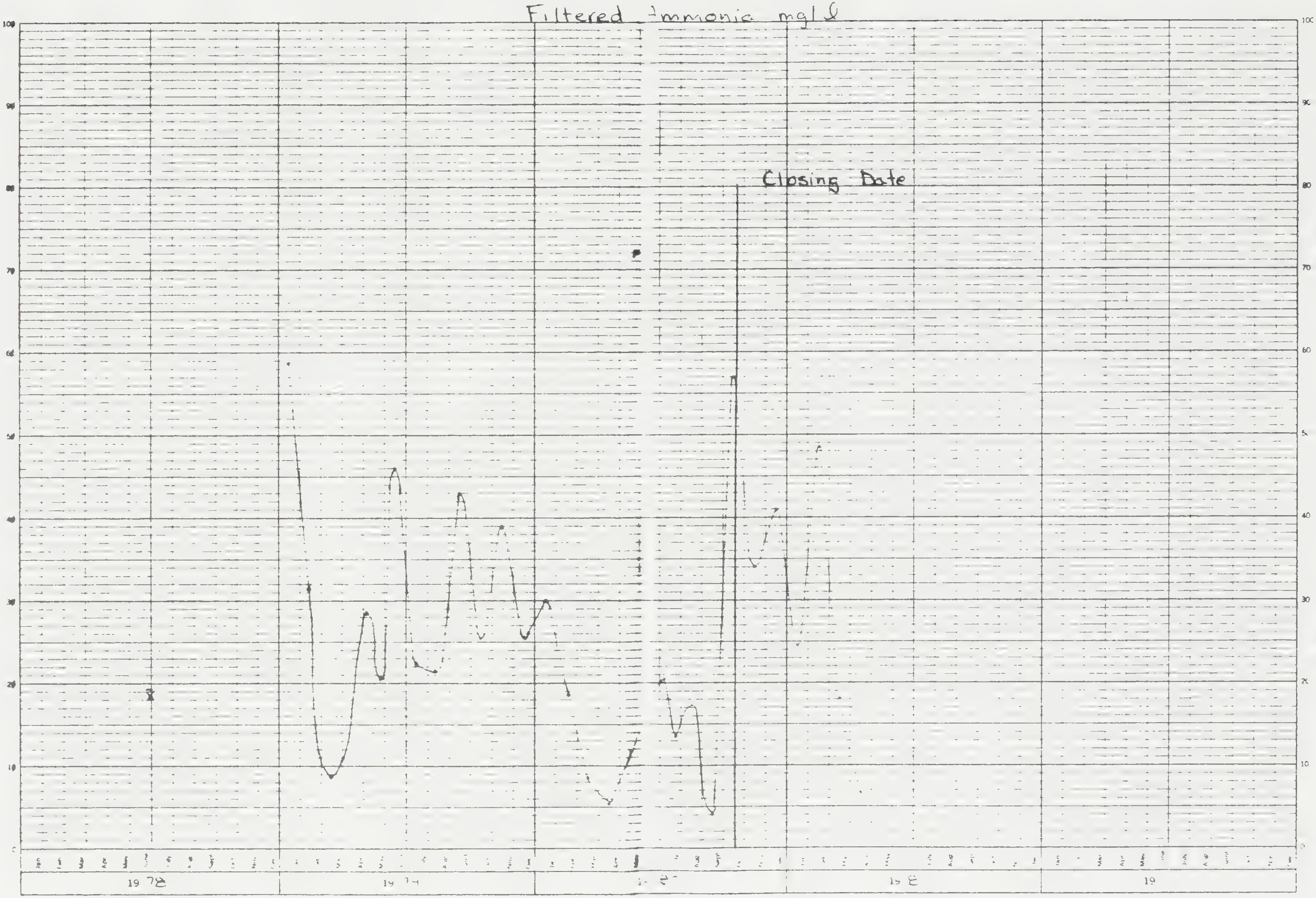


47 3653

K+E 5 YEARS BY MONTHS X 100 DIVISIONS
KEUFFEL & ESSER CO. MADE IN U.S.A.

Redhill Creek at Mount Albion Falls (RH 11)

Filtered Ammonia mg/l



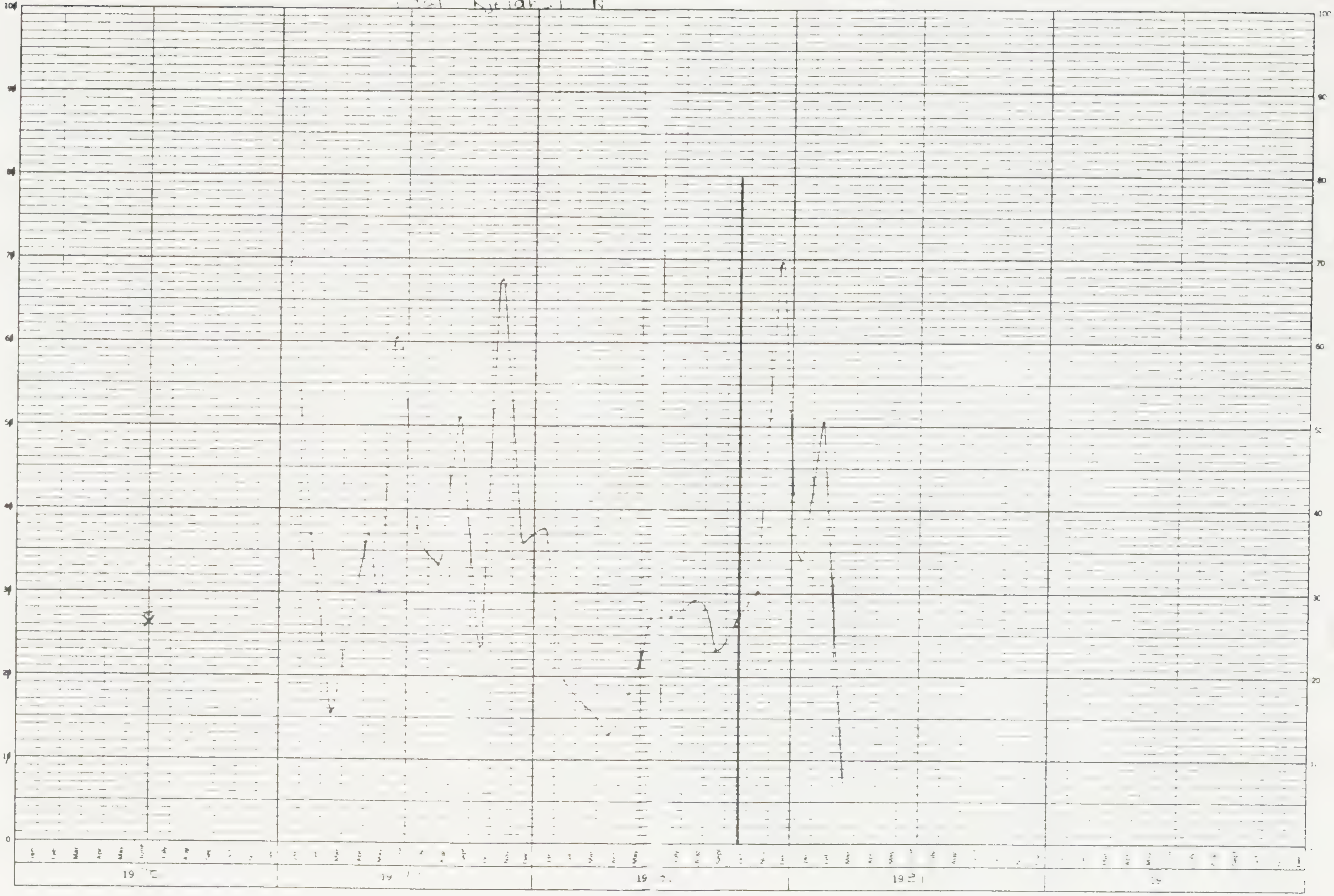
x value only

K•E 5 YEARS BY MONTHS X 100 DIVISIONS
KEUFFEL & ESSER CO. MADE IN U.S.A.
47 3653

6 9

Fishtrap Creek at Mount [illegible] Falls ([illegible])

Total Kjeldahl N



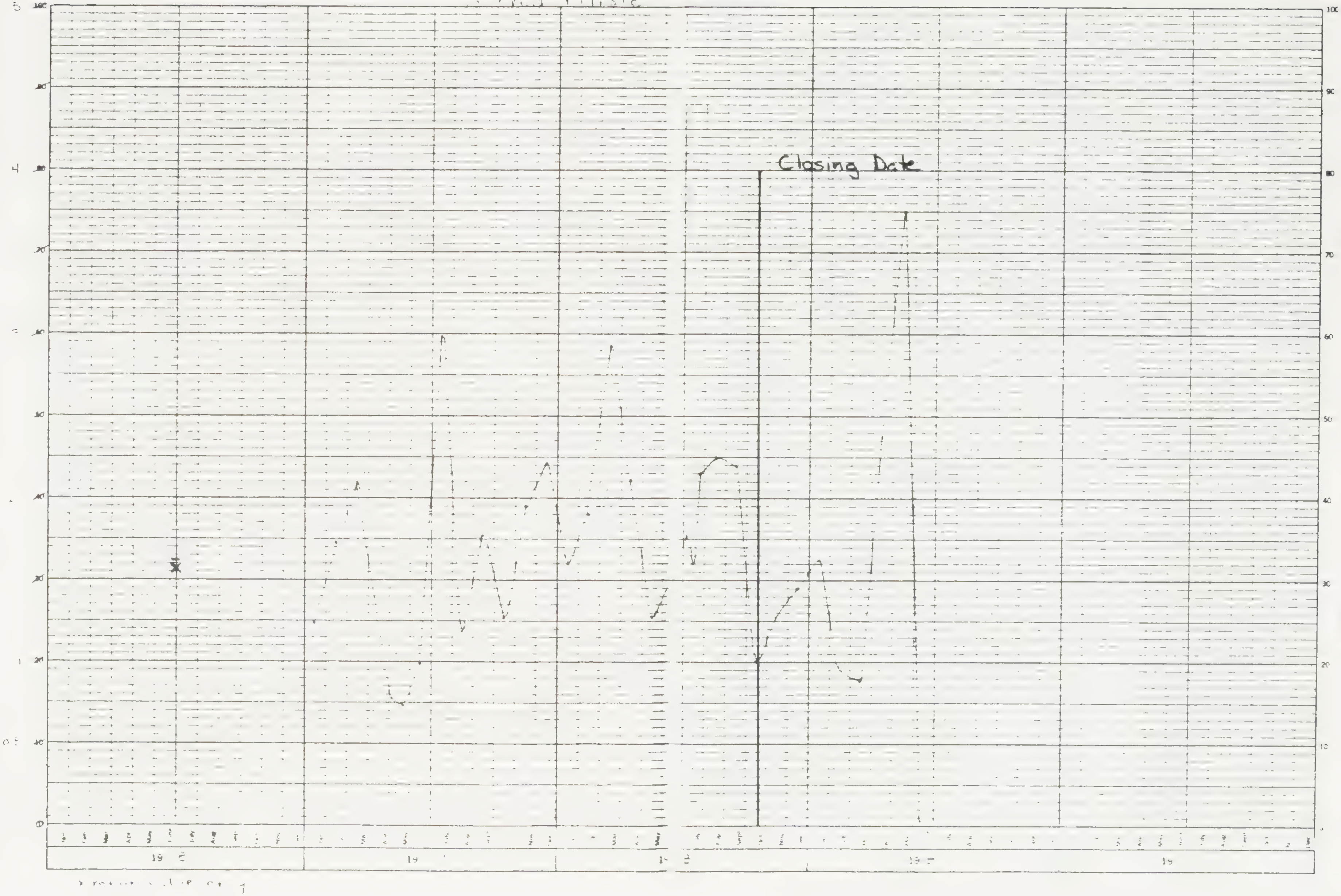
K+E 5 YEARS BY MONTHS X 100 DIVISIONS
KEUFFEL & ESSER CO. MADE IN U.S.A.

47 3653

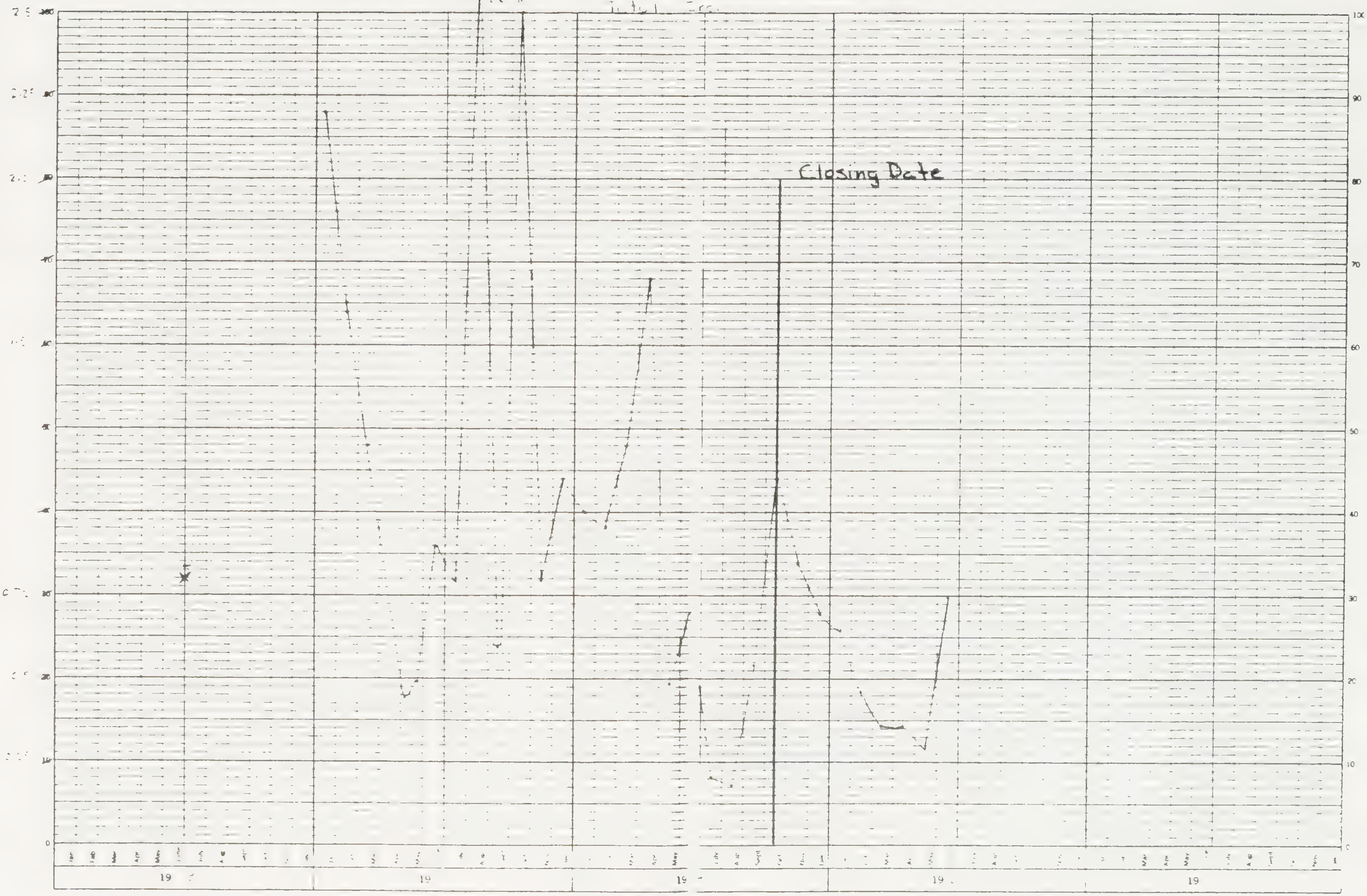
6 10

[illegible]

[illegible] Nitrate



6 11 [illegible] Albert [illegible]

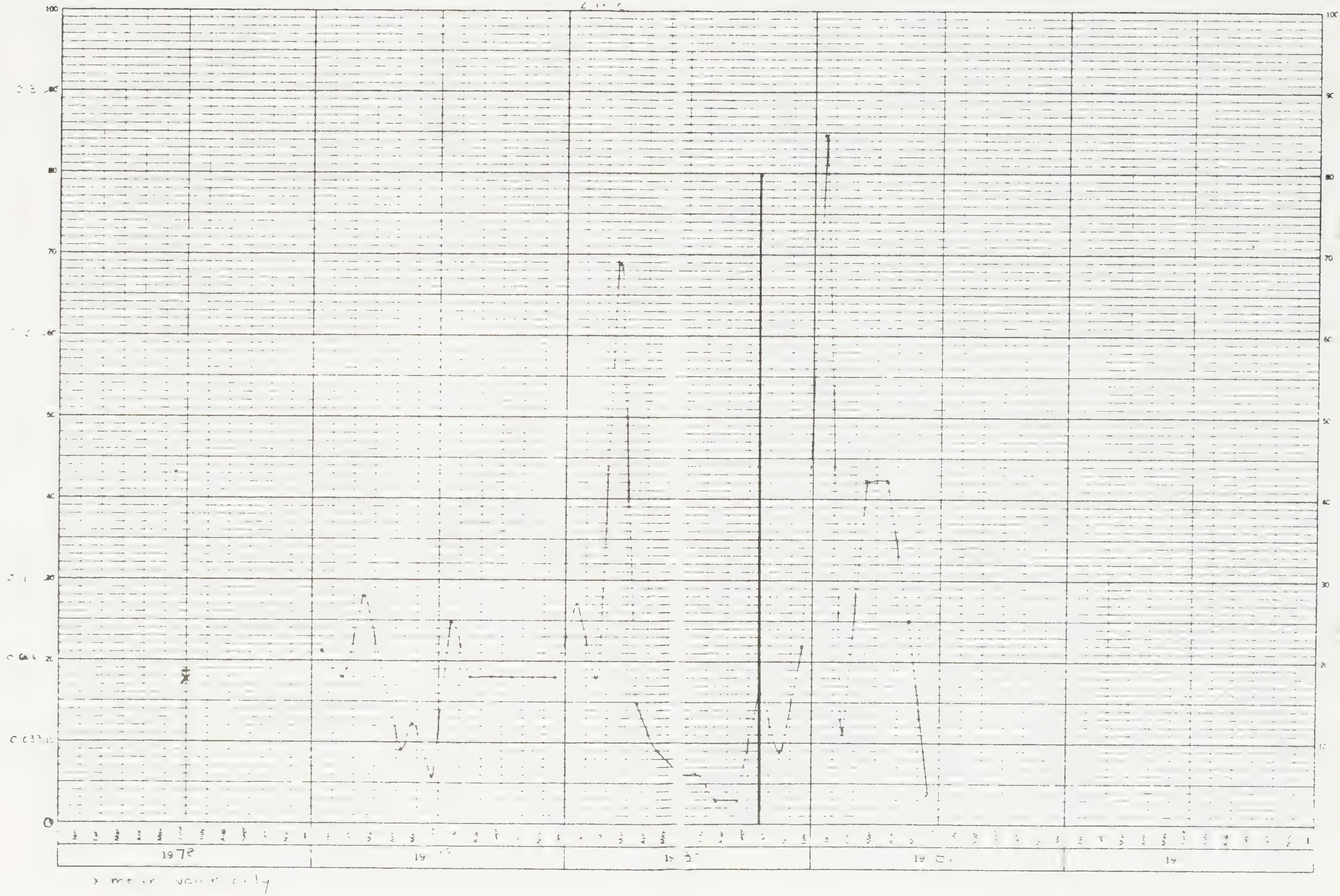


47 3653

K+E 5 YEARS BY MONTHS X 100 DIVISIONS
KEUFFEL & ESSER CO. MADE IN U.S.A.

6 12 Indian Creek at Mount Airy [illegible] Falls [illegible]

Zinc

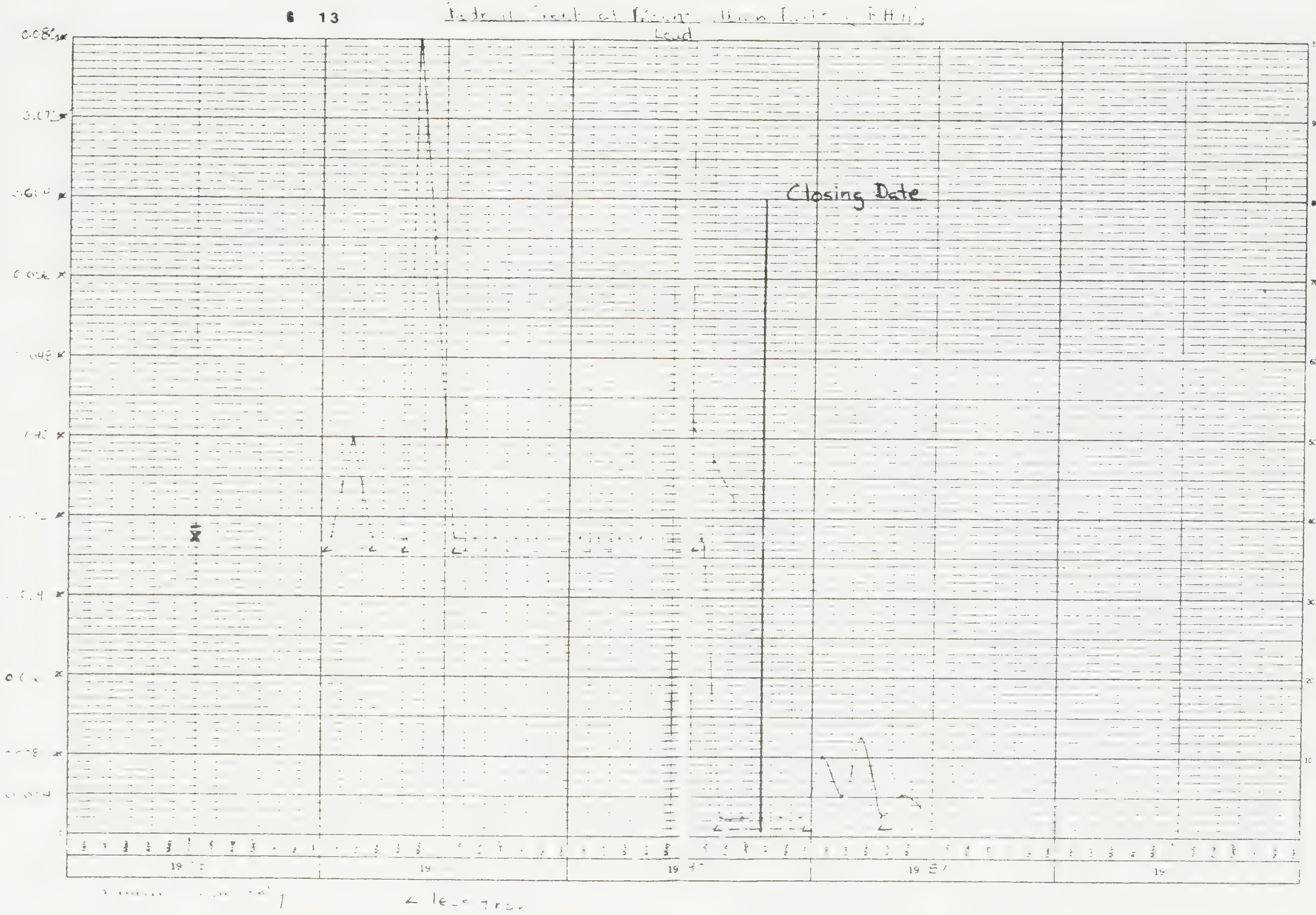


x mean value only

K-E 5 YEARS BY MONTHS X 100 DIVISIONS
KEUFFEL & ESSER CO. MADE IN U.S.A.

47 3653

6 13



K+E 5 YEARS BY MONTHS X 100 DIVISIONS
KEUFFEL & ESSER CO. MADE IN U.S.A.

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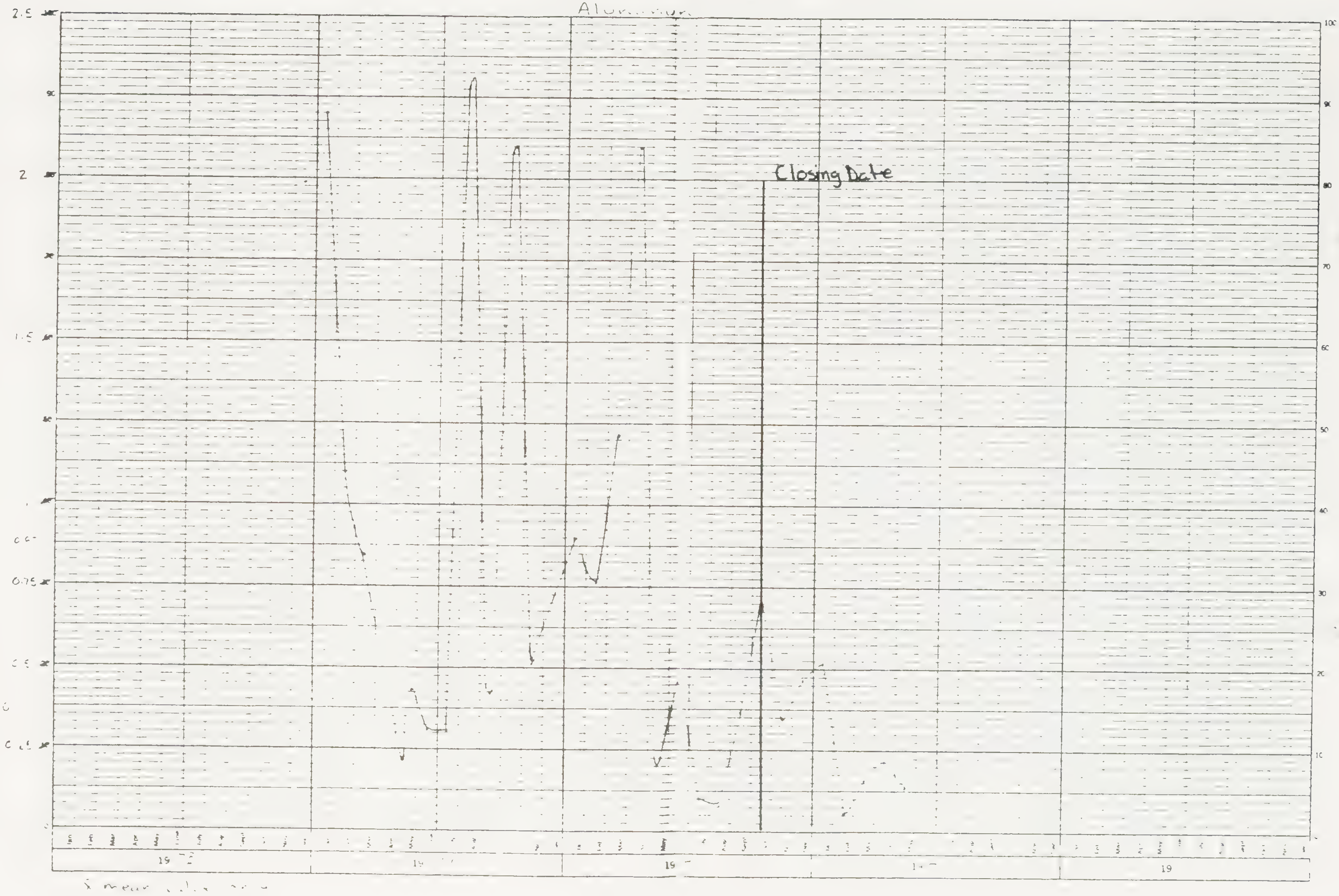
Redhill Creek at Mount Albion Falls (TH)

Aluminum



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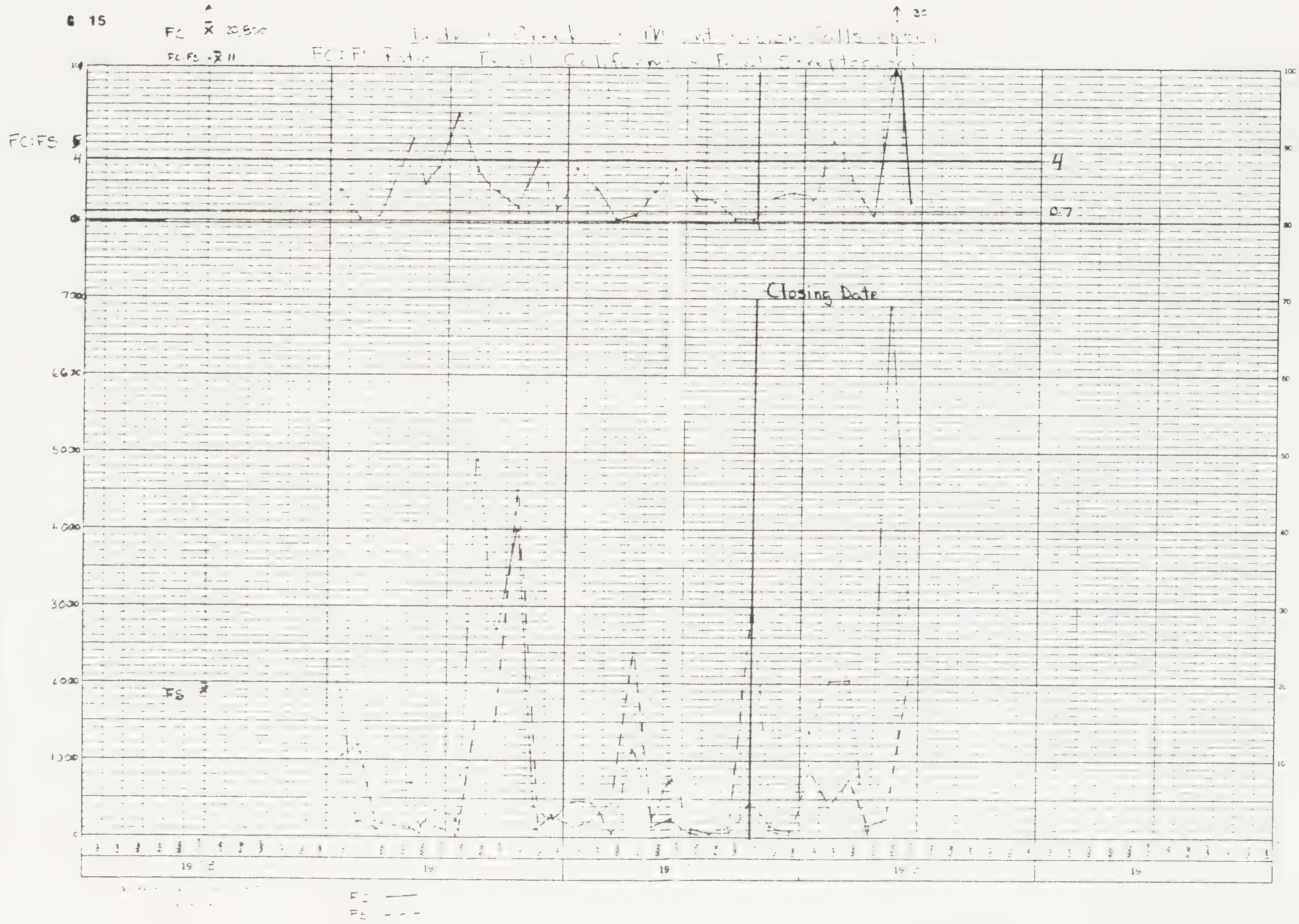

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K+E 5 YEARS BY MONTHS X 100 DIVISIONS
KEUFFEL & ESSER CO. MADE IN U.S.A.

APPENDIX III

Redhill Creek Surface Water Site # 1 Table

Sample Date	Chlorides	Alkalinity	pH	COD	BOD5	Total Solids	Suspended Solids	Conductivity	Turbidity	Free Ammonia	Total Kjeldahl	Nitrite	Nitrate	Total Phosphorus	Soluble Phosphate
31/10/79 GL	150		7.8	29	0			1000		11.0	14.2		1.20		
08/04/80 GL	105		8.1	22	1.1			720		0.75	1.74				
08/04 80 MOE	113	183	8.3	31	2.0	845	45	1050	30	0.7	1.0	0.06	2.0	0.06	< 0.02
* $\bar{X}$	11.3	183	8.3	31	2.0	845	45	1050	30	0.7	1.0	0.06	2.0	0.06	< 0.02
* θn															

Redhill Creek Surface Water Site # 2 RH / 3

Sample Date	Chlorides	Alkalinity	pH	COD	BOD5	Total Solids	Suspended Solids	Conductivity	Turbidity	Free Ammonia	Total Kjeldahl	Nitrite	Nitrate	Total Phosphorus	Soluble Phosphate
29/07/79 MOE	206	180	8.2	67	10	1340	17	1650	3.4	5.0	6.8	1.2	2.7	0.08	< 0.02
31/10/79 GL	150		8.1	29	0			950		11.0	14.2		1.20		
08/04/80 GL	127		8.2	15	2.9			700		1.45	2.70				
08/04/80 MOE	136	215	8.2	31	2.0	910	45	1250	32	1.4	1.5	0.08	1.8	0.06	0.02
16/07/80 MOE	218	443	7.8	46	3.5	1692	415	2050	3.0	0.3	7.4	0.76	2.9	< 0.02	< 0.02
26/05/81 MOE	259	223	7.91	117	2.0	1406	5	2000		0.014	4.45	7.25	7.23	0.039	0.0
23/07/81 MOE	267	128	7.90	138	2.0	1371	17	2100		0.006	3.00	0.006	4.60	0.052	0.0[illegible]
* $\bar{X}$	217	237	8.00	40	4	1393	20	1810	12.8	2.54	4.63	1.86	3.85	0.05	0.019
* θn	47	109	0.17	17	3	250	13	322	13.6	2.62	2.23	2.73	1.92	0.02	0.005

* MOE data

Redhill Creek Surface Water Site # 3

Sample Date		Chloride	Alkalinity	pH	COD	BOD5	Total Solids	Suspended Solids	Conductivity	Turbidity	Free Ammonia	Total Kjeldahl	Nitrite	Nitrate	Total Phosphorus	Soluble Phosphorus
31/10/79.	GL.	115		8.2	7	0			800		8.0	11.0		1.18		
08/04/80	GL.	122		8.1	18	2.4			700		1.10	2.40				
08/04/80	MOE	133	209	8.1	31	1.6	1920	45	1220	2.8	1.0	1.2	0.08	1.7	0.06	0.02
* $\bar{x}$		133	209	8.1	31	1.6	1920	45	1220	2.8	1.0	1.2	0.08	1.7	0.06	0.02
* σ_n																

Redhill Creek Surface Water Site # 4 RH 14

24/07/79	MOE	97	166	8.1	<20	1.6	1115	25	1310	30	0.12	0.8	0.07	1.2	0.12	0.06
31/10/79	GL	85		7.7	7	0			700		0.12	2.1		0.52		
08/04/80	GL	157		8.0	16	2.1			720		0.10	1.40				
08/04/80	MOE	163	210	8.0	<20	1.4	980	95	1330	28	<0.1	0.6	0.08	1.7	0.10	0.02
25/06/81	MOE	215	194	8.13	13	0.8	1283	10	1750		0.004	0.53	0.022	1.250	0.056	0.033
23/07/81	MOE	173	215	8.00	30	1.0	1243	20	1750		0.012	0.58	0.051	2.150	0.095	0.0
* $\bar{x}$		162	196	8.06	<21	1.12	1155	38	1535	15.5	0.079	0.63	0.056	1.575	0.092	0.040
* σ_n		42	19	0.06	< 6	0.3	119	34	215	12.5	0.079	0.10	0.022	0.385	0.023	0.015

* MOE data

Redhill Creek Surface Water Site # 5 RH 12

Sample Date	Chloride	Alkalinity	pH	COD	BOD5	Total Solids	Suspended Solids	Conductivity	Turbidity	Free Ammonia	Total Kjeldahl	Nitrite	Nitrate	Total Phosphorus	Soluble Phos
31/10/79 GL	135		7.7	7	0			950		0.04	2.5		0.04		
08/04/80 GL	73		8.15	7	1.1			550		<0.02	0.70				
08/04/80 MOE	76	156	8.4	23	0.6	675	20	880	52	<0.10	0.40	0.03	2.0	0.04	<0.02
16/07/80 MOE	11.5	171	7.9	<20	0.4	1350	<15	1580	6.5	<0.10	0.40	0.02	0.40	<0.02	<0.02
25/06/81 MOE	125	193	7.94	19	0.4	1190	6	1480		0.02	0.29	0.061	0.745	0.014	<0.001
23/07/81 MOE	120	219	7.98	32	0.8	907	23	1360		0.004	0.80	0.022	5.00	0.080	0.037
* $\bar{x}$	109	185	8.06	24	0.55	1031	16	1325	29.3	0.056	0.47	0.033	2.036	0.039	<0.020
* σ_n	19	24	0.20	5	0.17	259	6	268	22.8	0.044	0.19	0.016	1.812	0.026	<0.013

Redhill Creek Surface Water Site # 6 RH 15

Sample Date	Chloride	Alkalinity	pH	COD	BOD5	Total Solids	Suspended Solids	Conductivity	Turbidity	Free Ammonia	Total Kjeldahl	Nitrite	Nitrate	Total Phosphorus	Soluble Phos
08/04/80 GL	106		8.15	41	1.1			700		0.60	1.70				
08/04/80 MOE	113	185	8.2	23	2.0	785	30	1100	13	0.5	0.8	0.08	2.0	0.04	<0.02
23/07/81 MOE		254	7.38	101	2.0	2151	7	3500		0.430	0.98	0.095	0.105	0.060	0.023
* $\bar{x}$	113	220	7.79	62	2.0	1468	19	2300	13	0.47	0.89	0.088	1.05	0.05	0.02
* σ_n	0	35	0.41	39	0	683	12	1200	0	0.04	0.09	0.008	0.95	0.01	0.00

* MOE data

Redhill Creek Surface Water Site # 7

Sample Date		Chloride	Alkalinity	pH	COD	BOD5	Total Solids	Suspended Solids	Conductivity	Turbidity	Free Ammonia	Total Kjeldahl	Nitrite	Nitrate	Total Phosphorus	Soluble Phosphorus
08/04/80	GL	131		8.00	26	0.9			700		<0.02	1.20				
08/04/80	MOE	143	198	7.7	27	0.6	665	< 15	1040	17	<0.1	0.4	0.02	0.8	0.02	<0.02
* $\bar{x}$		143	198	7.7	27	0.6	665	< 15	1040	17	<0.1	0.4	0.02	0.8	0.02	<0.02
* σ_n																

Redhill Creek Surface Water Site # RH 16

Sample Date		Chloride	Alkalinity	pH	COD	BOD5	Total Solids	Suspended Solids	Conductivity	Turbidity	Free Ammonia	Total Kjeldahl	Nitrite	Nitrate	Total Phosphorus	Soluble Phosphorus
24.07/79	MOE	4120	4867	8.2	2000	110	12000	155	17600	20	300	380	0.10	0.1	3.0	2.1
16/07/80	MOE	3880	2840	8.4	280	210	11700	190	16900	71000	265	362	0.10	0.20	3.3	1.8
25/06/81	MOE	259	214	7.96	48	2.2	1426	5	1950		0.052	4.82	0.008	6.750	0.36	0.003
* $\bar{x}$		2753	2640	8.19	776	107.4	8375	117	12150	> 510	188.35	248.94	0.069	2.35	2.22	1.30
* σ_n		1766	1905	0.18	871	84.0	4915	80	7218	490	133.91	172.78	0.043	3.11	1.32	0.93

* MOE data

Redhill Creek Surface Water Site # 1

Sample	Date	Total Iron	Zinc	Copper	Nickel	Lead	Cadmium	Chromium	Aluminum	Arsenic	Manganese
31/10/79	GL	0.3									
08.04/80	GL	0.30	<0.05	<0.2	<0.05	<0.05	<0.02	ND			
08/04/80	MOE	1.2	0.03	<0.01	<0.02	<0.03	<0.005	<0.02	0.93	0.002	
* $\bar{X}$		1.2	0.03	<0.01	<0.02	<0.03	<0.005	<0.02	0.93	0.002	
* σ_n											

Redhill Creek Surface Water Site # 2 RH 13

24/07/79	MOE	0.22	<0.01	<0.01	<0.02	<0.03	<0.005	<0.02	0.09		0.05
31/10/79	GL	0.2									
08/04/80	GL	0.70	<0.05	<0.2	<0.05	<0.05	<0.02	ND			
08/04/80	MOE	1.4	0.06	<0.01	<0.02	<0.03	<0.005	<0.02	1.1	0.001	
16/07/80	MOE	0.23	0.068	0.015	0.01		0.007	0.003	<0.18		0.079
26/05/81	MOE	0.260	0.075	0.023	0.006	<0.003	<0.0001	0.006	0.320		0.080
23/07/81	MOE	0.500	0.073	0.006	0.008	<0.003	<0.0001	0.006	0.470		0.060
* $\bar{x}$		0.522	0.057	<0.013	<0.013	<0.017	0.003	0.011	0.432	0.001	0.073
* σ_n		0.451	0.024	0.006	0.006	<0.014	0.003	0.007	0.358		0.009

* MOE data

Redhill Creek Surface Water Site # 3

Sample Date		Total Iron	Zinc	Copper	Nickel	Lead	Cadmium	Chromium	Aluminum	Arsenic	Manganese
31/10/79	GL	0.1									
08/04/80	GL	0.50	<0.42	<0.2	<0.05	<0.05	<0.02	ND			
08/04/80	MOE	1.4	0.07	<0.01	<0.02	<0.03	<0.005	<0.02	1.2	0.002	
* $\bar{x}$		1.4	0.07	<0.01	<0.02	<0.03	<0.005	<0.02	1.2	0.002	
* σ_n											

Redhill Creek Surface Water Site # 4 R.H. 14

Sample Date		Total Iron	Zinc	Copper	Nickel	Lead	Cadmium	Chromium	Aluminum	Arsenic	Manganese
24/07/79	MOE	2.9	0.09	<0.01	<0.02	<0.03	<0.005	<0.02	0.26		0.04
31/10/79	GL	0.1									
08/04/80	MOE	2.9	0.11	0.01	0.02	<0.03	<0.005	<0.02	2.0	0.002	
08/04/80	GL	0.85	<1.40	<0.2	<0.05	<0.015	<0.02	ND			
25/06/81	MOE	0.300	0.130	0.018	<0.001	<0.003	0.0002	<0.005	0.340		0.110
23/07/81	MOE	0.82	0.150	0.012	0.007	<0.003	<0.0001	0.007	0.760		0.074
* $\bar{x}$		1.73	0.095	0.013	0.012	<0.017	<0.0026	0.013	0.073	0.002	0.075
* σ_n		1.18	0.054	0.003	0.008	<0.014	<0.0024	0.007	0.108	0	0.029

* MOE data

Redhill Creek Surface Water Site # 5 RH 12

Sample Date		Total Iron	Zinc	Copper	Nickel	Lead	Cadmium	Chromium	Aluminum	Arsenic	Manganese
31/10/79	GL	0.2									
08/04/80	GL	0.15	<0.60	<0.2	<0.05	<0.05	<0.02	ND			
08/04/80	MOE	0.70	<0.01	<0.01	<0.02	<0.03	<0.005	<0.02	0.73	0.002	
16/07/80	MOE	0.32	0.032	0.03	0.009	ND	ND	<0	0.43		<0.033
25/06/81	MOE	0.120	0.013	0.017	<0.0005	<0.003	0.0001	0.004	0.360		0.070
23/07/81	MOE	1.08	0.029	0.005	0.006	<0.003	<0.0001	0.005	0.920		0.076
* $\bar{x}$		0.55	0.021	0.016	0.009	<0.012	<0.002	0.007	0.578	0.002	0.060
* σn		0.37	0.010	0.009	0.007	<0.013	<0.002	0.008	0.257	0	0.019

Redhill Creek Surface Water Site # 6 RH 15

Sample Date		Total Iron	Zinc	Copper	Nickel	Lead	Cadmium	Chromium	Aluminum	Arsenic	Manganese
08/04/80	GL	0.30	<0.150	<0.2	<0.05	<0.05	<0.02	ND			
08/04/80	MOE		0.04	<0.01	<0.02	<0.03	<0.005	<0.02	0.83	<0.001	
23/07/81	MOE	0.94	0.008	0.009	0.006	<0.003	0.0001	0.009	0.44		0.665
* $\bar{x}$		0.94	0.024	0.010	0.013	<0.017	0.003	0.015	0.64	<0.001	0.665
* σn		0	0.016	0.001	0.007	<0.014	0.002	0.006	0.20	0	0

* MOE data

Redhill Creek Surface Water Site # 7

Sample Date		Total Iron	Zinc	Copper	Nickel	Lead	Cadmium	Chromium	Aluminum	Arsenic	Manganese
08/04/80	GL	0.25	<0.60	<0.2	<0.05	<0.05	<0.02	ND			
08/04/80	MOE		<0.01	<0.01	<0.02	<0.03	<0.005	<0.02	<0.06	<0.001	
* x̄			<0.01	<0.01	<0.02	<0.03	<0.005	<0.02	<0.06	<0.001	
* σn											

Redhill Creek Surface Water Site # RH 1.6

Sample Date		Total Iron	Zinc	Copper	Nickel	Lead	Cadmium	Chromium	Aluminum	Arsenic	Manganese
24/07/79	MOE	7.0	1.2	0.40	0.39	<0.30	<0.05	0.55	9.7		12
16/07/80	MOE	8.2	0.38	0.13	0.30	0.72	0.020	0.34	5.9		0.48
25/06/81	MOE	0.330	0.081	0.019	0.003	0.01	0.001	0.006	0.340		0.09
* x̄		5.18	0.55	0.183	0.218	0.34	0.024	0.299	5.31		4.19
* σn		3.46	0.47	0.160	0.153	0.29	0.020	0.224	3.84		5.52

* MOE data

Redhill Creek Surface Water Site # RH 17

Sample Date	Total Iron	Zinc	Copper	Nickel	Lead	Cadmium	Chromium	Aluminum	Arsenic	Manganese
16 07/80 MOE	0.18	0.049	0.034	0.012	0.011	0	0.003	0.21		0.037
* $\bar{x}$	0.18	0.049	0.034	0.012	0.011	0	0.003	0.21		0.037
* σ_n										

Redhill Creek Surface Water Site # RH 13

Sample Date	Total Iron	Zinc	Copper	Nickel	Lead	Cadmium	Chromium	Aluminum	Arsenic	Manganese
16/07/80 MOE	31	0.62	0	0.38	0.26	0	0.26	17		0.74
25/06/81 MOE	5.50	0.460	0.085	0.300	0.110	0.002	0.260	1.40		0.22
* $\bar{x}$	18.3	0.54	0.043	0.34	0.185	0.001	0.260	9.2		0.48
* σ_n	12.8	0.08	0.043	0.04	0.075	0.001	0	7.8		0.26

* MOE data

Redhill Creek Surface Water Site # 1

Sample Date	PCB	HCB	α BHC	β BHC	Lindane	Hepta-Chlor	Hept. Epoxide	Thiodan I	Thiodan II	Aldrin	Dieldrin	Endrin	ppDDE	opDDT	ppDDD	ppDDT	α Chlordane	γ Chlordane	Mirex	Phenols
31/10/79. G.L																				3
08/04/80. G.L																				0
08/04/80. MOE	x	x	x	x	x	x		x	x	x	x	x	x	x	x	x	x	x	x	<1
* $\bar{x}$	x	x	x	x	x	x		x	x	x	x	x	x	x	x	x	x	x	x	<1
* σn																				

Redhill Creek Surface Water Site # 2 RH 13

Sample Date	PCB	HCB	α BHC	β BHC	Lindane	Hepta-Chlor	Hept. Epoxide	Thiodan I	Thiodan II	Aldrin	Dieldrin	Endrin	ppDDE	opDDT	ppDDD	ppDDT	α Chlordane	γ Chlordane	Mirex	Phenols
24/07/79 MOE																				3
31/10/79. G.L																				4
08/04/80 G.L																				2
08/04/80 MOE																				<1
16/07/80 MOE																				1
23/07/81 MOE	<20																			
* $\bar{x}$	<20																			1.7
* σn																				0.9

* MOE data

Redhill Creek Surface Water Site # 3

Sample Date	PCB	HCB	α BHC	βBHC	Lindane	Hepta-Chlor	Hept. Epoxide	Endosulfan I	Endosulfan II	Aldrin	Dieldrin	Endrin	pp'DDE	op'DDT	pp'DDD	pp'DDT	α Chlordane	γ Chlordane	Mirex	Phenols
31/10/79 GL																				1
08/04/80 GL																				0
08/04/80 MOE																				<1
* x̄																				<1
* σn																				

Redhill Creek Surface Water Site # 4 R.H. 14

Sample Date	PCB	HCB	α BHC	βBHC	Lindane	Hepta-Chlor	Hept. Epoxide	Endosulfan I	Endosulfan II	Aldrin	Dieldrin	Endrin	pp'DDE	op'DDT	pp'DDD	pp'DDT	α Chlordane	γ Chlordane	Mirex	Phenols
24/07/79 MOE																				3
31/10/79 GL																				1
08/04/80 GL																				0
08/04/80 MOE	x	x	0.001	x	x	x		x	x	x	x	x	x	x	x	x	x	0.001	x	1
25/06/81 MOE	<20																			<1
23/07/81 MOE	<20																			
* x̄	<20	x	0.001	x	x	x		x	x	x	x	x	x	x	x	x	x	0.001	x	1.7
* σn	0																			0.9

* MOE data

Redhill Creek Surface Water Site # 5 RH 12

Sample Date	PCB	HCB	α BHC	β BHC	Lindane	Hepta-Chlor	Hepta Epoxide	Thiodan I	Thiodan II	Aldrin	Dieldrin	Endrin	pp DDE	op DDT	pp DDD	pp DDT	α Chlordane	γ Chlordane	Mirex	Phenols
31/10/79 GL																				1
08/04/80 GL																				0.15
08/04/80 MOE																				<1
16/07/80 MOE																				<1
* $\bar{x}$																				<1
* σn																				

Redhill Creek Surface Water Site # 6 RH 15

08/04/80 GL																				0
08/04/80 MOE																				<1
* $\bar{x}$																				<1
* σn																				

* MOE data

Redhill Creek Surface Water Site # 7

Sample Date	PCB	HCB	α BHC	βBHC	Lindane	Hepta-Chlor	Hept. Epoxide	Thiodan I	Thiodan II	Aldrin	Dieldrin	Endrin	ppDDE	opDDT	ppDDD	ppDDT	α Chlordane	γ Chlordane	Mirex	Phenols
08/04/80 GL																				0.25
08/04/80 MOE																				<1
* $\bar{x}$																				<1
* σ_n																				

Redhill Creek Surface Water Site # RH 16

Sample Date	PCB	HCB	α BHC	βBHC	Lindane	Hepta-Chlor	Hept. Epoxide	Thiodan I	Thiodan II	Aldrin	Dieldrin	Endrin	ppDDE	opDDT	ppDDD	ppDDT	α Chlordane	γ Chlordane	Mirex	Phenols
24/07/79 MOE																				150
08/04/80 MOE																				<1
* $\bar{x}$																				75.5
* σ_n																				74.5

* MOE data

Redhill Creek Surface Water Site # RH 17

Sampl. Date	PCB	HCB	α BHC	β BHC	Lindane	Hepta-Chlor	Hept. Epoxide	Thiodan I	Thiodan II	Aldrin	Dieldrin	Endrin	ppDDE	opDDT	ppDDD	ppDDT	α Chlordane	γ Chlordane	Mirex	Phenols
16/07/80 MCE																				1
* $\bar{x}$																				1
* σ_n																				

Redhill Creek Surface Water Site # RH 18

16/07/80 MCE																				5
* $\bar{x}$																				5
* σ_n																				

* MCE data

Redhill Creek Surface Water Site # 1

All counts /100 ml

Sample Date		Total Coliform	Background Count	Fecal Coliform	Fecal Streptococci	FC : FS Ratio
Redhill Creek Surface Water Site # 2 RH 13						
23/07/79.	MOE	370000	780000	200	6000	0.03
24/07/79.	MOE	16000	260000	2100	510	4.12
16/07/80	MOE	6000	180000	760	740	1.03
11/06/81	MOE	12000	920000	1500	140	10.71
23/07/81	MOE	41000	240000	71500	710	
Gm x̄		4.45	5.58	2.97	2.87	1.48
		28086	381301	936	742	1.57

Redhill Creek Surface Water Site # 3

All counts /100 ml

Sample Date	Total Coliform	Background Count	Fecal Coliform	Fecal Streptococci	FC : FS Ratio
Redhill Creek Surface Water Site # 4				RH 1.4	
23/07/79 MOE	57000	107000	> 1500	1500	> 1
24/07/79 MOE	84000	280000	14000	2040	6.86
16/07/80 MOE	12000	71000	1760	560	3.14
11/06/81 MOE	11000	71000	1200	240	5.00
23/07/81 MOE	85000	260000	> 1500	1160	> 1.29
G.M. $\bar{x}$	455	512	336	294	$\bar{x}$ 3.46
	35 158	131 467	2315	862	σ_n 2.23

Redhill Creek Surface Water Site # 5 RH 12

All counts /100 ml

Date		Total Coliform	Background Count	Fecal Coliform	Fecal Streptococci	FC : FS Ratio
16/07/80	MOE	4000	33000	380	380	1.00
11/06/81	MOE	1800	67000	120	380	0.32
23/07/81	MOE	17000	240000	890	7,500	0.59
Gm x̄		3.70 4965	4.91 80959	2.54 344	2.78 600	x̄ 0.64 Gm 0.23

Redhill Creek Surface Water Site # 6 RH 15

23/07/81	1300	56000	150	400	0.38
GM x̄	3.11 1300	4.75 56000	2.18 150	2.60 400	x̄ 0.38 Gm [illegible]

Redhill Creek Surface Water Site # 7

All counts / 100 ml

Sample Date	Total Coliform	Background Count	Fecal Coliform	Fecal Streptococci	FC : FS Ratio

Redhill Creek Surface Water Site # RH 16

28/07/79 MOE	100	14900	30	30	1.0
24/07/79 MOE	17000	260000	400	1140	0.35
16/07/80 MOE	280000	6000000	3200	40000	0.08
11/06/81 MOE	9000	150000	1100	310	3.55
GM x̄	3.91	5.39	2.53	2.91	x̄ 1.25
	8090	242997	337	807	σ_n 1.37

Redhill Creek Surface Water Site # RH 17

All counts /100 ml

Sample Date		Total Coliform	Background Count	Fecal Coliform	Fecal Streptococci	FC : FS Ratio
16/07/80	MOE	6000	100000	860	1160	0.74
G m x̄		3.78 6000	5. 100000	2.93 860	3.06 1160	x̄ 0.74 σn 0

Redhill Creek Surface Water Site # RH 18

16/07/80	MOE	150000	8000000	6900	200000	0.03
11/06/81	MOE	90000	11200000	300	79000	0.004
G m x̄		5.07 116190	6.98 9465728	3.16 1439	5.10 125698	x̄ 0.017 σn 0.013

Borehole # 1 Piezometer #1

Sample Date	PCB	HCB	α BHC	β BHC	Lindane	Hepta-chlor	Hept. Epoxide	Thiodan I	Thiodan II	Aldrin	Dieldrin	Endrin	pp DDE	op DDT	pp DDD	pp DDT	α Chlordane	γ Chlordane	Mirex	Phenols
31/10/79 GL																				18
03/12/79 GL																				12
07/01/80 GL																				16
08+16/04/80 GL																				4.
08/04/80 MOE	X																			1
01/05/80 MOE																				3
25/06/81 MOE	< 20.																			< 1
* x̄	< 20																			1.7
* σn																				0.9

Borehole # 2 Piezometer #1

07/01/80 GL																				69
10/04/80 MOE	X																			
01/05/80 MOE																				525
12/05/80 GL																				0.36
12/05/80 MOE																				70
* x̄																				29
* σn																				

* MOE data

Borehole # 1 Piezometer # 1

Sample Date	Chloride	Alkalinity	pH	COD	BOD5	Total Solids	Suspended Solids	Conductivity	Turbidity	Free Ammonia	Total Kjeldahl	Nitrite	Nitrate	Total Phosphorous	Soluble Phosphorous
31.10/79. GL	115		7.7	290	10			2400			5.0				
03.11/79. GL	24		7.35	300	119			3200			3.7				
07.01/80. GL	125		7.4	620	65			3300			12				
08.04/80 GL	175		7.65	68	174			2700			8				
18.04/80. MOE	122	266	7.5	190	220	4340	405	4100	165	4.5	5.0	0.3	0.1	0.54	0.14
03.06/80. MOE	127	147	7.2	430		4430	525	4340	94	3.4	5.5	0.1	< 0.1	0.40	0.92
25/06/81 MOE	101	200	7.90	249	95	3660	40	4000		4.2	5.0	0.01	< 0.1	0.08	0.08
* $\bar{x}$	117	204	7.5	290	158	4143	323	4147	130	4.0	5.2	0.14	0.1	0.34	0.08
* σ_n	11	49	0.3	102	63	344	206	143	36	0.5	0.2	0.12	0	0.19	0.05

Borehole # 2 Piezometer # 1

Sample Date	Chloride	Alkalinity	pH	COD	BOD5	Total Solids	Suspended Solids	Conductivity	Turbidity	Free Ammonia	Total Kjeldahl	Nitrite	Nitrate	Total Phosphorous	Soluble Phosphorous
07.01/80. GL	40		7.3	1650	220			9500			230				
01/05/80. MOE	8420	10 900	8.0	2400		9600	1020	25000		2560	6500	0.35	0.2	19.	0.10
12.05/80. GL	2240	9700	7.9	2279	75						1964				
12.05/80 MOE	2390	9900	7.8	2200		12500	5480	19500		2300	2400	0.45	0.8	15.	4.9
* $\bar{x}$	5405	10400	7.9	2300		11050	3250	22250		2430	4700	0.40	0.5	17.	2.5
* σ_n	3015	500	0.1	100		1450	2230	2750		130	1800	0.05	0.3	2	2.4

* MOE data

Borehole # 2 Standpipe # 2

Smpl. Date	PCB	HCB	α BHC	βBHC	Lindane	Hepta-chlor	Hept. Epoxide	Thiodan I	Thiodan II	Aldrin	Dieldrin	Endrin	ppDDE	opDDT	ppDDD	ppDDT	α Chlordane	γ Chlordane	Mirex	Phenols
07/01/80 GL																				464
~~08~~16/04/80 GL																				288
14/04/80 GL	0.02																			
14/04/80 MOE																				340
* $\bar{x}$																				340
* σn																				
Borehole # 4 Piezometer #1																				
03/12/79 GL																				96
12/05/80 GL																				1.70
12/05/80 MOE																				65
* $\bar{x}$																				65
* σn																				

* MOE data

Borehole # 2 Standpipe # 2

Sample Date	Chloride	Alkalinity	pH	COD	BOD$_5$	Total Solids	Suspended Solids	Conductivity	Turbidity	Free Ammonia	Total Kjeldahl	Nitrite	Nitrate	Total Phosphorous	Soluble Phosphorous
27/02:80 GL	10		7.3	3450	520			24000			500				
[illegible] 4/80 GL	2750		7.3	3647	140			17500			1760				
14:04:80 MOE	2860	11500	7.6	4000	130	16200	7420	25400		2750	2900	0.20	0.5	19.	8.4
* $\bar{x}$	2860	11500	7.6	4000	130	16200	7420	25400		2750	2900	0.20	0.5	19.	8.4
* σ_n															

Borehole # 4 Piezometer # 1

Sample Date	Chloride	Alkalinity	pH	COD	BOD$_5$	Total Solids	Suspended Solids	Conductivity	Turbidity	Free Ammonia	Total Kjeldahl	Nitrite	Nitrate	Total Phosphorous	Soluble Phosphorous
12/05:80 GL	1755	434	7.8	632	175						120				
12/05:80 MOE	2190	1430	7.8	2200		9220	4400	6700		2300	2900	0.45	0.8	15.	4.9
* $\bar{x}$	2190	1430	7.8	2200		9220	4400	6700		2300	2900	0.45	0.8	15.	4.9
* σ_n															

* MOE data

Borehole # 4 Standpipe # 2

Sampl. Date	PCB	HCB	α BHC	β BHC	Lindane	Hepta-chlor	Hept. Epoxide	Thiodan I	Thiodan II	Aldrin	Dieldrin	Endrin	pp DDE	op DDT	pp DDD	pp DDT	α Chlordane	γ Chlordane	Mirex	Phenols
03/12/79 G.L																				180
* x̄																				
* σn																				

Borehole # 6 Piezometer # 1

Sampl. Date	PCB	HCB	α BHC	β BHC	Lindane	Hepta-chlor	Hept. Epoxide	Thiodan I	Thiodan II	Aldrin	Dieldrin	Endrin	pp DDE	op DDT	pp DDD	pp DDT	α Chlordane	γ Chlordane	Mirex	Phenols
31/10/79 G.L																				18
03/12/79 G.L																				8
07/01/80 G.L																				12
08+10/04/80 G.L																				4
08/04/80 MOE	X																			1
01/05/80 MOE																				5
25/06/81 MOE	< 20																			2
* x̄	< 20																			2.7
* σn																				1.7

* MOE data

Borehole # 4 Standpipe # 2

Sample Date		Chloride	Alkalinity	pH	COD	BOD5	Total Solids	Suspended Solids	Conductivity	Turbidity	Free Ammonia	Total Kjeldahl	Nitrite	Nitrate	Total Phospherous	Soluble Phospherous
22.2.80	GL	58		7.20	3529	164			2100			44				
* x̄		58		7.20	3524	164			2100			44				
* σn																

Borehole # 6 Piezometer # 1

Sample Date		Chloride	Alkalinity	pH	COD	BOD5	Total Solids	Suspended Solids	Conductivity	Turbidity	Free Ammonia	Total Kjeldahl	Nitrite	Nitrate	Total Phospherous	Soluble Phospherous
31/10/79	GL	740		7.6	515	100			2100			5.0				
03/12/79	GL	125		7.25	[illegible]	114			5000			1.2				
07/01/80	GL	1950		7.2	270	55			6000			44				
05&16/04/80	GL	3065		7.35	241	54			7200			5.6				
08/04/80	MOE	3350	2430	7.0	496	86	26400	17700	11000	71000	3.2	10	0.2	0.1	8.8	< 0.02
01/05/80	MOE	2430	110	7.3	1000		2370	215	9350	125	3.0	8.0	0.06	0.2	0.35	< 0.02
2/06/80	MOE	3046	78	6.70	476	60			10300		3.8		0.02	0.1	0.08	< 0.02
* x̄		2942	873	7.0	662	73	[illegible]	8958	10217	563	3.3	9.0	0.09	0.1	3.08	< 0.02
* σn		383	1101	0.24	224	13	4515	8743	676	438	0.3	1.0	0.08	0.05	4.05	0

* MOE data

Borehole # 7 Piezometer # 1

Sample Date	Chloride	Alkalinity	pH	COD	BOD5	Total Solids	Suspended Solids	Conductivity	Turbidity	Free Ammonia	Total Kjeldahl	Nitrite	Nitrate	Total Phosphorous	Soluble Phosphorous
03/12/79 GL	84		7.45	956	24			4000			5.7				
07/01/80 GL	875		7.4	250	10			3100			2.4				
16/04/80 GL	1720		7.45	74	34			5000			3.48				
10/04/80 MOE	1470	331	7.0	160	58	5690	520	6650	225	2.2	3.2	0.1	0.1	0.44	0.10
01/05/80 MOE	8420	2530	7.2	795		42400	23500	24700	71000	10	35	0.06	0.3	21.	0.02
25/06/81 MOE	1479	202	6.90		55			6500		2.2	4.0	0.02	<0.1	0.100	<0.02
* x̄	3142	1021	7.0	475	57	24045	[illegible]	12617	613	4.8	14.1	0.06	0.2	7.18	0.05
* σn	3274	1008	0.1	315	2	18355	[illegible]	8544	388	3.7	14.8	0.03	0.1	9.77	0.04
** x̄	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	6575	[illegible]	[illegible]	[illegible]	0.06	[illegible]	[illegible]	[illegible]
** σn	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	75	[illegible]	[illegible]	0.4	[illegible]	[illegible]	0.17	[illegible]

** [illegible] data [illegible] only

Borehole # 8 Piezometer # 1

Sample Date	Chloride	Alkalinity	pH	COD	BOD5	Total Solids	Suspended Solids	Conductivity	Turbidity	Free Ammonia	Total Kjeldahl	Nitrite	Nitrate	Total Phosphorous	Soluble Phosphorous
08/04/80 MOE	7540	201	6.7	37	22	15800	420	20500	130	7.0	7.6	0.01	0.1	0.18	<.02
01/05/80 MOE	5080	382	7.5	280		12900	700	16800	325	5.8	13.	0.03	0.3	2.5	.02
25/06/81 MOE	4254	270	7.0	278	34			12800		5.5	6.4	0.01	<0.1	0.08	.02
* x̄	5641	284	7.1	198	28	14350	560	16700	228	6.1	9.0	0.02	0.02	0.92	.02
* σn	1419	75	0.3	114	6	1450	140	3144	98	0.6	2.9	0.01	0.01	1.12	0

* MOE data

Borehole # 9 Piezometer # 1

Sample Date		Chloride	Alkalinity	pH	COD	BOD5	Total Solids	Suspended Solids	Conductivity	Turbidity	Free Ammonia	Total Kjeldahl	Nitrite	Nitrate	Total Phosphorous	Soluble Phosphorous
31/10/79	GL	1580		7.0	470	10			6500			93				
03/12/79	GL	45		7.10	325	63			7000			92.5				
08/[illegible]/80	GL	1305		7.4	500	154			6000			177				
08/04/80	MOE	1590	1500	6.7	400	40	6970	95	9400	130	150	152	0.01	0.1	0.20	0.02
01/05/80	MOE	1570	1280	7.4	350		6770	370	9050	110	144	140	0.03	0.2	0.60	0.04
* $\bar{x}$		1580	1390	7.1	375	42	6870	232	9225	120	147	146	0.02	0.15	0.4	0.03
* σ_n		10	1[illegible]	0.4	25	0	100	138	175	10	3	6	0.01	0.05	0.2	0.01

Borehole # 9 Standpipe # 2

Sample Date		Chloride	Alkalinity	pH	COD	BOD5	Total Solids	Suspended Solids	Conductivity	Turbidity	Free Ammonia	Total Kjeldahl	Nitrite	Nitrate	Total Phosphorous	Soluble Phosphorous
01/[illegible]/80	GL		1280	6.8	550	32			8000			12.5				
[illegible]/04/80	GL		1760	7.0	618	294			6000			170				
08/04/80	MOE	1560	1490	6.8	410	48	6860	45	9300	150	140	142	0.01	0.1	0.12	0.04
25/04/81	MOE	1808	1625	6.9	520	66			9500		15.6	0.3	0.01	< 0.1	0.16	< 0.0[illegible]
* $\bar{x}$		1684	1555	6.85	[illegible]	57	6860	45	9400	150	142	71.2	0.01	< 0.1	0.14	0.02
* σ_n		124	8	0.05	[illegible]	9	0	0	100	0	8	70.9	0	< 0.1	0.02	0.0[illegible]

* MOE data

Borehole # 11 Piezometer # 1

Sample Date		Chloride	Alkalinity	pH	COD	BOD5	Total Solids	Suspended Solids	Conductivity	Turbidity	Free Ammonia	Total Kjeldahl	Nitrite	Nitrate	Total Phosphorus	Soluble Phosphorus
[illegible] 16/24/80	G.L	110		7.6	200	24			315			9.2				
[illegible]/04/80	MOE	2320	157	7.2	270	14	9920	160	13300	70	1.8	12.0	0.01	0.1	0.10	< 0.02
[illegible]05/80	MOE	5660	144	8.0	< 20		14800	1210	18200	200	0.1	8.5	0.01	0.3	0.50	< 0.[illegible]
* $\bar{X}$		3990	151	7.6	145	14	12360	685	15750	135	0.95	10.25	0.01	0.2	0.3	0.0[illegible]
* S_n		1670	6.5	0.4	125	0	2440	525	2450	65	0.85	1.75	0	0.1	0.2	0.0[illegible]

Borehole # 11 Standpipe # 2

Sample Date		Chloride	Alkalinity	pH	COD	BOD5	Total Solids	Suspended Solids	Conductivity	Turbidity	Free Ammonia	Total Kjeldahl	Nitrite	Nitrate	Total Phosphorus	Soluble Phosphorus
25/06/81	MOE	7015	154	7.8	878	205			19000		6.2	6.4	< 0.01	< 0.1	0.10	0.08
* $\bar{Y}$		7015	154	7.8	878	205			19000		6.2	6.4	< 0.01	< 0.1	0.10	0.08
* S_n																

* MOE data

Borehole # 12 Piezometer #1

Sampl. Date	Chloride	Alkalinity	pH	COD	BOD5	Total Solids	Suspended Solids	Conductivity	Turbidity	Free Ammonia	Total Kjeldahl	Nitrite	Nitrate	Total Phosphorus	Soluble Phosphorus
25/06/81 MOE	84.7	380	7.1	140	6.0			3600		< 0.1	2.2	0.01	0.01	0.16	< 0.02
* $\bar{x}$	84.7	380	7.1	140	6.0			3600		< 0.1	2.2	0.01	0.01	0.16	< 0.02
* σ_n															

Borehole # ___

* MOE data

Borehole # 1 Piezometer # 1

Sample Date		Total Iron	Zinc	Copper	Nickel	Lead	Cadmium	Chromium	Aluminum	Arsenic	Manganese
31/10/79	GL	11.5									
03/12/79	GL	1.76									
07/01/80	GL	250									
01/05/80	MOE	5.5	0.91	6.1	< 0.20	0.43	< 0.05	< 0.20	14	< 0.01	
25/06/81	MOE	0.45	0.03	0.03	< 0.01	0.01	< 0.01	.01	0.20		0.05
* $\bar{x}$		2.98	0.47	3.07	< 0.11	0.22	< 0.03	0.11	7.1	< 0.01	0.05
* σ_n		2.53	0.44	3.04	< 0.10	0.21	< 0.02	0.10	6.9	0	0

Borehole # 2 Piezometer # 1

Sample Date		Total Iron	Zinc	Copper	Nickel	Lead	Cadmium	Chromium	Aluminum	Arsenic	Manganese
07/01/80	GL	270									
01/25/80	MOE	47	3.3	49	1.5	0.31	< 0.05	< 0.20	14	< 0.01	
12/25/80	MOE	1.78	30	0.92	1.0	2.2	< 0.05	4.4	110	0.06	
* $\bar{x}$		1.13	16.7	24.96	1.25	1.26	< 0.05	2.3	62	0.04	
* σ_n		66	13.4	24.04	0.25	0.95	0	2.1	48	0.03	

* MOE data

Borehole # 2 Standpipe #2

Sample Date		Total Iron	Zinc	Copper	Nickel	Lead	Cadmium	Chromium	Aluminum	Arsenic	Manganese		
07/01/80	GL	21											
18/04/80	MOE	190	100	54	4.4	43		17	1800				
* $\bar{X}$		190	100	54	4.4	43		17	1800				
* Θ n													

Borehole # 4 Piezometer #1

Sample Date		Total Iron	Zinc	Copper	Nickel	Lead	Cadmium	Chromium	Aluminum	Arsenic	Manganese		
03/12/79	GL	430											
12/05/80	MOE	232	7.2	1.9	1.2	0.61	0.06	1.5	39	0.06			
* $\bar{X}$		232	7.2	1.9	1.2	0.61	0.06	1.5	39	0.06			
* Θ n													

* MOE data

Borehole # 7 Piezometer #1

Sampl. Date	P.C.B	H C B	α B H C	β B H C	Lindane	Hepta-chlor	Hept. Epoxide	Thiodan I	Thiodan II	Aldrin	Dieldrin	Endrin	pp DDE	op DDT	pp DDD	pp DDT	α Chlordane	γ Chlordane	Mirex	Phenols
03/12/79 GL																				0
07/01/80 GL																				4
~~08~~16/04/80 GL																				4
08/04/80 MOE																				1
01/05/80 MOE																				V6
25/06/80 MOE	56																			
* x̄	56																			15
* σn	0																			
** x̄																				
** σn																				

** elimination of 01/05/80 MOE data (for this borehole only)

Borehole # 8 Piezometer #1

Sampl. Date	P.C.B	H C B	α B H C	β B H C	Lindane	Hepta-chlor	Hept. Epoxide	Thiodan I	Thiodan II	Aldrin	Dieldrin	Endrin	pp DDE	op DDT	pp DDD	pp DDT	α Chlordane	γ Chlordane	Mirex	Phenols
08/04/80 MOE	x																			3
01/05/80 MOE																				1
25/06/81 MOE	<20																			1
* x̄	<20																			17
* σn																				0

* MOE data

Borehole # 4 Standpipe # 2

Sample Date		Total Iron	Zinc	Copper	Nickel	Lead	Cadmium	Chromium	Aluminum	Arsenic	Manganese
03/12/79	GL	88									
* $\bar{x}$		88									
* σ_n											

Borehole # 6 Piezometer # 1

Sample Date		Total Iron	Zinc	Copper	Nickel	Lead	Cadmium	Chromium	Aluminum	Arsenic	Manganese
31/10/79	GL	1									
03/12/79	GL	2									
07/01/80	GL	8									
08/04/80	MOE	470	0.03	0.05	0.02	<0.03	<0.065	<0.02	0.62	0.002	
01/05/80	MOE	6.6	0.28	2.3	<0.20	<0.30	<0.05	<0.20	6.3	<0.01	
25/06/81	MOE	1.20	0.03	0.05	.01	<0.01	<0.001	0.02	0.78		0.52
* $\bar{x}$		159.3	0.11	0.8	0.08	<0.11	<0.014	<0.08	2.57	0.006	0.52
* σ_n		219.7	0.12	1.06	0.09	<0.13	<0.022	<0.08	2.64	0.004	0

* MOE data

Borehole # 7 Piezometer # 1

Sample Date		Total Iron	Zinc	Copper	Nickel	Lead	Cadmium	Chromium	Aluminum	Arsenic	Manganese
03/12/79	GL	48									
07/01/80	GL	49									
08/04/80	MOE		2.1	0.14	0.11	0.72	<0.005	0.16	61	0.016	
10/04/80	MOE	10.4	0.82	2.0	0.02	0.20	0.06	0.06	13	0.008	
01/05/80	MOE	115	0.73	9.5	<0.20	<0.30	<0.05	<0.20	7.9	<0.01	
25/06/81	MOE	0.35									
* $\bar{x}$		41.9	1.22	3.9	0.11	0.41	<0.038	0.14	27.3	0.011	
* σ_n		51.8	0.63	4.0	0.07	0.23	<0.024	0.06	23.9	0.003	
** $\bar{x}$		[illegible]	[illegible]	1.1	0.07	0.46	[illegible]	[illegible]	[illegible]	0.012	
** σ_n		[illegible]	0.4	[illegible]	0.09	[illegible]	0.029	0.05	34	0.004	

** elimination of all MOE data for this borehole only)

Borehole # 8 Piezometer # 1

Sample Date		Total Iron	Zinc	Copper	Nickel	Lead	Cadmium	Chromium	Aluminum	Arsenic	Manganese
08/04/80	MOE	9.2	0.08	0.04	0.03	<0.03	<0.005	0.04	4.8	0.002	
01/05/80	MOE	19	0.69	9.5	<0.20	<0.30	<0.05	<0.20	8.3	<0.01	
25/06/81	MOE	<0.40	<0.01	0.01	<0.01	<0.01	<0.001	<0.01	0.04		0.07
* $\bar{x}$		9.5	0.26	3.18	<0.08	<0.11	<0.019	<0.08	4.38	0.006	0.07
* σ_n		7.6	0.31	4.47	<0.09	<0.13	<0.022	<0.08	3.39	0.004	0

* MOE data

Borehole # 9 Piezometer #1

Sample Date		PCB	HCB	α BHC	BBHC	Lindane	Hepta-chlor	Hept. Epoxide	Thiodan I	Thiodan II	Aldrin	Dieldrin	Endrin	ppDDE	opDDT	ppDDD	ppDDT	α Chlordane	γ Chlordane	Mirex	Phenols
31/10/79	GL																				12
03/12/79	GL																				70
08+16/04/80	GL																				4
08/04/80	MOE	X	X	0.008	X	X	X		X	X	X	0.030	0.007	X	X	X	X	X	X	X	2
01/05/80	MOE																				1
* x̄		X	X	0.008	X	X	X		X	X	X	0.030	0.007	X	X	X	X	X	X	X	1.5
* σn																					[illegible]

Borehole # 9 Standpipe #2

Sample Date		PCB	HCB	α BHC	BBHC	Lindane	Hepta-chlor	Hept. Epoxide	Thiodan I	Thiodan II	Aldrin	Dieldrin	Endrin	ppDDE	opDDT	ppDDD	ppDDT	α Chlordane	γ Chlordane	Mirex	Phenols
07/01/80	GL																				12
08+14/04/80	GL																				4
08/04/80	MOE	X																			2
25/06/81	MOE	<20																			1
* x̄		<20																			1.5
* σn																					0.5

* MOE data

Borehole # 9 Piezometer # 1

Sample Date		Total Iron	Zinc	Copper	Nickel	Lead	Cadmium	Chromium	Aluminum	Arsenic	Manganese
31/10/79	GL	18									
03/12/79	GL	3									
08/04/80	MOE	2.4	0.03	0.04	0.04	<0.03	<0.005	<0.02	1.3	0.004	
01/05/80	MOE	6.6	0.54	4.8	<0.20	<0.30	<0.05	<0.20	2.9	<0.01	
* $\bar{x}$		4.5	0.29	2.42	0.12	<0.16	<0.0275	<0.11	2.1	0.007	
* σ_n		2.1	0.26	2.38	0.08	<0.14	<0.022	<0.09	0.8	0.003	

Borehole # 9 Standpipe # 2

Sample Date		Total Iron	Zinc	Copper	Nickel	Lead	Cadmium	Chromium	Aluminum	Arsenic	Manganese
07/01/80	GL	12									
08/04/80	MOE	1.2	<0.01	0.05	0.03	<0.03	<0.005	<0.02	0.55	0.002	
25/02/81	MOE	0.20	0.05	0.05	0.04	<0.01	<0.001	0.01	0.14		0.04
* $\bar{x}$		0.7	<0.03	0.05	0.035	<0.02	<0.003	<0.015	0.35	0.002	0.04
* σ_n		0.5	<0.02	0	0.005	<0.01	<0.002	<0.005	0.21	0	0

* MOE data

Borehole # 11 Piezometer # 1

Sample Date	PCB	HCB	α BHC	β BHC	Lindane	Hepta-chlor	Hept. Epoxide	Thioden I	Thioden II	Aldrin	Dieldrin	Endrin	ppDDE	opDDT	ppDDD	ppDDT	α Chlordane	γ Chlordane	Mirex	Phenols
~~08~~16/04/80 GL																				4
08/04/80 MOE	X	X	0.020	0.002	0.001	X		X	X	X	0.030	0.008	X	X	X	X	X	0.002	X	1
01/05/80 MOE																				28
* $\bar{x}$	X	X	0.020	0.002	0.001	X		X	X	X	0.030	0.008	X	X	X	X	X	0.002	X	14.5
* σ_n																				5

Borehole # 11 Standpipe # 2

Sample Date	PCB	HCB	α BHC	β BHC	Lindane	Hepta-chlor	Hept. Epoxide	Thioden I	Thioden II	Aldrin	Dieldrin	Endrin	ppDDE	opDDT	ppDDD	ppDDT	α Chlordane	γ Chlordane	Mirex	Phenols
08/04/80 MOE																				1
25/06/81 MOE	26																			1
* $\bar{x}$	26																			
σ_n	0																			

* MOE data

Borehole # 11 Piezometer # 1

Sample Date		Total Iron	Zinc	Copper	Nickel	Lead	Cadmium	Chromium	Aluminum	Arsenic	Manganese
08/04/80	MOE	4.0	0.11	0.04	0.02	<0.03	<0.005	<0.02	4.4	0.002	
01/05/80	MOE	6.2	0.39	4.4	<0.20	<0.30	<0.05	<0.20	5.6	<0.01	
+ $\bar{x}$		5.1	0.25	2.22	<0.11	<0.17	<0.028	<0.11	5.0	<0.006	
* σ_n		1.1	0.14	2.18	<0.09	<0.14	<0.023	<0.09	0.6	<0.004	

Borehole # 11 Standpipe # 2

Sample Date		Total Iron	Zinc	Copper	Nickel	Lead	Cadmium	Chromium	Aluminum	Arsenic	Manganese
25/06/81	MOE	0.32	0.03	0.04	<0.01	<0.01	0.001	0.21	0.35		0.09
+ $\bar{x}$		0.32	0.03	0.04	<0.01	<0.01	0.001	0.21	0.35		0.09
* σ_n											

MoE data

Borehole # 12 Piezometer # 1

Sample Date	PCB	HCB	α BHC	β BHC	Lindane	Hepta-chlor	Hept. Epoxide	Thiodan I	Thiodan II	Aldrin	Dieldrin	Endrin	pp DDE	op DDT	pp DDD	pp DDT	α Chlordane	γ Chlordane	Mirex	Phenols
25/06/81 MOE	< 20.																			< 1.
* $\bar{x}$	< 20.																			< 1.
* σ_n																				

Borehole # ___

* MOE data

Borehole # 12 Piezometer # 1

Sample Date	Total Iron	Zinc	Copper	Nickel	Lead	Cadmium	Chromium	Aluminum	Arsenic	Manganese	
25/06/81 MOE	4.90	2.60	0.05	0.04	0.05	0.002	0.01	3.20		0.52	
* $\bar{x}$	4.90	2.60	0.05	0.04	0.05	0.002	0.01	3.20		0.52	
* σ_n											

Borehole #

* MOE data

Groundwater at Upper Ottawa Landfill Site : Parameter Means Compared to Provincial Drinking Water Crite

	Site #	Chloride	Alkalinity	pH	COD	BOD5	Total Solids	Dissolved Solids	Conductivity	Turbidity	Free Ammonia	Total Kjeldahl	Nitrite	Nitrate	Total Phosphorus	Soluble Phosphorus
$\bar{x}$	BH # 1 P#1	11.7	20.4	7.5	290	15.8	4143	3820	4147	130	4.0	5.2	0.14	0.1	0.34	0.08
$\bar{x}$	BH # 2 P#1	5405	10400	7.9	2300		11050	7800	22250		2430	4700	0.40	0.15	17	2.5
$\bar{x}$	BH # 2 SP#2	2860	11500	7.6	4000	130	16200	8780	25400		2750	2900	0.20	0.5	19	8.9
$\bar{x}$	BH # 4 P#1	219.0	143.0	7.8	2200		9220	4820	16700		2300	2900	0.45	0.8	15	4.9
$\bar{x}$	BH # 4 SP#2															
$\bar{x}$	BH #6 P#1	2942	87.3	7.0	662	7.3	16885	7927	10217	563	3.3	9.0	0.09	0.1	3.08	< 0.02
$\bar{x}$	BH# 7 P#1	379.0	102.1	7.0	475	5.7	24045	12035	12617	613	4.8	14.1	0.06	0.2	7.18	0.05
$\bar{x}$	BH #8 P#1	564.1	28.4	7.1	198	2.8	14350	13790	16700	228	6.1	9.0	0.02	0.02	0.92	0.02
$\bar{x}$	BH #9 P#1	1580	139.0	7.1	375	40	6870	6637	9225	120	147	146	0.02	0.15	0.4	0.07
$\bar{x}$	BH #9 SP#2	168.4	155.8	6.85	465	5.7	6860	6215	9400	150	148	71.2	0.01	< 0.1	0.14	0.03
$\bar{x}$	BH #11 P#1	399.0	15.1	7.6	145	14	12360	11675	15750	135	0.95	10.25	0.01	0.2	0.3	0.06
$\bar{x}$	BH #11 SP#2	701.5	15.4	7.8	878	20.5			19000		6.2	6.4	< 0.01	< 0.1	0.10	0.08
$\bar{x}$	BH #12 P#1	84.7	380	7.1	140	6.0			3600		< 0.1	2.2	0.01	0.01	0.16	< 0.02
	MCE Drinking Water Quality Criteria	250						500				0.15		10.0		

Groundwater at Upper Ottawa Landfill Site: Parameter Means Compared to Provincial Drinking Water Criteria

[illegible]	#	Total Iron	Zinc	Copper	Nickel	Lead	Cadmium	Chromium	Aluminium	Arsenic	Manganese
BH #1	P#1	2.98	0.47	3.07	<0.11	0.22	<0.03	0.11	7.1	<0.01	0.05
BH #2	P#1	11.3	16.7	24.96	1.26	1.26	<0.05	2.3	62	0.04	
BH #2	SP#2	190	100	54	4.4	43		17	1800		
BH #4	P#1	232	7.2	1.9	1.2	0.61	0.06	1.5	39	0.06	
BH #4	SP#2										
BH #6	P#1	159.3	0.11	0.8	0.08	<0.11	<0.019	<0.08	2.57	0.006	0.52
BH #7	P#1	41.9	1.22	3.9	0.11	0.41	<0.038	0.14	27.3	0.011	
BH #8	P#1	9.5	0.26	3.18	<0.08	<0.11	<0.019	<0.08	4.38	0.006	0.07
BH #9	P#1	4.5	0.29	2.42	0.12	<0.16	<0.275	<0.11	2.1	0.007	
BH #9	SP#2	0.7	<0.03	0.05	0.035	<0.02	<0.003	<0.015	0.35	0.002	0.04
BH #11	P#1	5.1	0.25	2.22	<0.11	<0.17	<0.028	<0.11	5.0	<0.006	
BH #11	SP#2	0.32	0.03	0.04	<0.01	<0.01	0.001	0.01	0.35		0.09
BH #12	P#1	4.90	2.60	0.05	0.04	0.05	0.002	0.01	3.20		0.52
		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
MoE Drinking Water Quality Criteria		0.3	5.0	1.0		0.05	0.01	0.05		0.01	0.05

Table 2-3

Surface Water: Redhill Creek - Parameter Means Compared to Provincial Drinking Water Criteria & Provincial Water Quality Objectives

	Site #	Chloride	Alkalinity	pH	COD	BOD5	Total Solids	Dissolved Solids	Conductivity	Turbidity	Free Ammonia	Total Kjeldhal	Nitrite	Nitrate	Total Phosphorous	Soluble Phosphorous
$\bar{x}$	Site #1	11.3	183	8.3	31	2.0	845	800	1050	30	0.7	1.0	0.06	2.0	0.06	<0.02
$\bar{x}$	Site #2 RH13	21.7	237	8.00	40	4.0	1343	1323	1810	12.8	2.54	4.63	1.86	3.85	0.05	0.019
$\bar{x}$	Site #3	133	209	8.1	31	1.6	920	875	1220	2.8	1.0	1.2	0.08	1.7	0.06	0.02
$\bar{x}$	Site #4 RH14	162	196	8.06	<21	1.2	1155	1117	1535	15.5	0.079	0.63	0.056	1.575	0.092	0.040
$\bar{x}$	Site #5 RH12	109	185	8.06	24	0.55	1031	1015	1325	29.3	0.056	0.47	0.033	2.036	0.039	<0.020
$\bar{x}$	Site #6 RH15	113	220	7.79	62	2.0	1468	1449	2300	13.0	0.47	0.89	0.088	1.05	0.05	0.02
$\bar{x}$	Site #7	143	198	7.7	27	0.6	665	650	1040	17.0	<0.1	0.4	0.02	0.8	0.02	<0.02
$\bar{x}$	Site # RH16	2753	2640	8.19	776	107.4	8375	8258	12150	7510	188.35	248.94	0.069	2.35	2.22	1.30
$\bar{x}$	Site # RH17	203	195	7.7	35	3.5	1630	1615	1950	1.5	4.4	7.6	0.52	2.4	0.04	0.02
$\bar{x}$	Site # RH18	3410	4297	8.39	4008	248	14135	13641	17750	71000	424	560	0.18	0.100	4.20	1.31
$\bar{x}$	Site # RH11	193	195	7.86	40.2	3.65	1142	1124	1597	13.5	2.43	3.44	0.30	1.69	0.06	0.012
	Prov Drinking Water Criteria	250						500				0.15		10.0		
	Prov. Water Quality Objectives (Protection of Aquatic Life)			6.5-8.5							0.02					

Surface Water: Redhill Creek Parameter Means Compared to Provincial Drinking Water Criteria & Provincial Water Quality Objectives

Site #	ppt PCB	HCB	α BHC	βBHC	Lindane	Hepta Chlor	Hept. Epoxide	Thiodan I	Thiodan II	Aldrin	Dieldrin	Endrin	ppDDE	opDDT	ppDDD	ppDDT	α Chlordane	γ Chlordane	Mirex	ppb Phenols
$\bar{x}$ Site #1	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	<1
$\bar{x}$ Site #2 RH13	< 20																			1.7
$\bar{x}$ Site #3																				<1
$\bar{x}$ Site #4 RH14	< 20	X	0.001	X	X	X		X	X	X	X	X	X	X	X	X	X	0.001	X	1.7
$\bar{x}$ Site #5 RH12																				<1
$\bar{x}$ Site #6 RH15																				<1
$\bar{x}$ Site #7																				<1
$\bar{x}$ Site # RH16																				75.5
$\bar{x}$ Site # RH17																				1.0
$\bar{x}$ Site # RH18																				5.0
$\bar{y}$ Site # RH11	X																			<1.18
Prov. Drinking Water Criteria	0 ppb				4.0	3.0				0.70		0.20	30.0				7.0			1.0 ppb
Prov Water Quality Objective (Protection of Aquatic Life)					0.1	0.001		0.003		0.001		0.02	0.003							1.0 ppb

Surface Water: Redhill Creek - Parameter Means Compared to Provincial Drinking Water Criteria & Provincial Water Quality Objectives

	Site #	Total Iron	Zinc	Copper	Nickel	Lead	Cadmium	Chromium	Aluminum	Arsenic	Manganese
x̄	Site #1	1.2	0.03	<0.01	<0.02	<0.03	<0.005	<0.02	0.93	0.002	
x̄	Site #2 RH13	0.522	0.057	<0.013	<0.013	0.017	0.003	0.011	0.432	0.001	0.073
x̄	Site #3	1.4	0.07	<0.01	<0.02	<0.03	<0.005	<0.02	1.2	0.002	
x̄	Site #4 RH14	1.73	0.095	0.013	0.012	<0.017	<0.0026	0.013	0.073	0.002	0.075
x̄	Site #5 RH12	0.55	0.021	0.016	0.009	<0.012	<0.002	0.007	0.578	0.002	0.060
x̄	Site #6 RH15	0.94	0.024	0.010	0.013	<0.017	0.003	0.015	0.64	<0.001	0.665
x̄	Site #7		<0.01	<0.01	<0.02	<0.03	<0.005	<0.02	<0.06	<0.001	
x̄	Site # RH16	5.18	0.55	0.183	0.218	0.34	0.024	0.299	5.31		4.19
x̄	Site # RH17	0.18	0.049	0.034	0.012	0.011	0	0.003	0.21		0.037
x̄	Site # RH18	18.3	0.54	0.043	0.34	0.185	0.001	0.260	9.2		0.048
ȳ	Site # RH11	0.93	0.071	<0.011	<0.015	<0.025	<0.004	<0.015	0.697	<0.001	0.169
	Prov. Drinking Water Criteria	0.3	5.0	1.0		0.05	0.01	0.05		0.01	0.05
	Prov Water Quality Objectives (Protection of Aquatic Life)	0.3	0.03	0.005	0.025	0.025	0.0002	0.1	0.1	0.1	

Surface Water: Redhill Creek Parameter Means Compared to Provincial Drinking Water Criteria & Provincial Water Quality Objectives

	Site #		Total Coliform	Background Count	Fecal Coliform	Fecal Streptococci	FC : FS Ratio	
Gmx̄	Site # 1							
Gmx̄	Site # 2	RH13	28086	381301	936	742	x̄	1.48
Gmx̄	Site # 3							
Gmx̄	Site # 4	RH14	35158	131467	2315	862	x̄	3.46
Gmx̄	Site # 5	RH12	4965	80959	344	600	x̄	0.64
Gmx̄	Site # 6	RH15	1300	56000	150	400	x̄	0.38
Gmx̄	Site # 7							
Gmx̄	Site #	RH16	8090	242997	337	807	x̄	1.25
Gmx̄	Site #	RH17	6000	100000	860	1160	x̄	0.74
Gmx̄	Site #	RH18	116190	9465728	1439	125698	x̄	0.02
Gmx̄	Site #	RH11	6220	36435	424	258	x̄	1.64
	Prov. Drinking Water Criteria		< 2		0			
	Prov Water Quality Objectives (Recreational Activities)		1000		100			

if the FC : FS ratio exceeds 4, the source is likely to be human in origin

if the FC : FS ratio is less than 0.7, the source is likely of non-human origin

if the FC:FS ratio is between 0.7–4, the source is likely to be a mixture

Surface Water: Redhill Creek - Parameter Means Compared to Provincial Drinking Water Criteria & Provincial Water Quality Objectives

Table F-1

	Site #	Chloride	Alkalinity	pH	COD	BOD5	Total Solids	Dissolved Solids	Conductivity	Turbidity	Free Ammonia	Total Kjeldhal	Nitrite	Nitrate	Total Phosphorus	Soluble Phosphorus
x̄	Site #1	11.3	183	8.3	31	2.0	845	800	1050	30	0.7	1.0	0.06	2.0	0.06	<0.07
x̄	Site #2 RH13	21.7	237	8.00	40	4.0	1343	1323	1810	12.8	2.54	4.63	1.86	3.85	0.05	0.019
x̄	Site #3	133	209	8.1	31	1.6	920	875	1220	2.8	1.0	1.2	0.08	1.7	0.06	0.02
x̄	Site #4 RH14	162	196	8.06	<21	1.2	1155	1117	1535	15.5	0.079	0.63	0.056	1.575	0.092	0.040
x̄	Site #5 RH12	109	185	8.06	24	0.55	1031	1015	1325	29.3	0.056	0.47	0.033	2.036	0.939	<0.020
x̄	Site #6 RH15	113	220	7.79	62	2.0	1468	1449	2300	13.0	0.47	0.89	0.088	1.05	0.05	0.[illegible]
x̄	Site #7	143	198	7.7	27	0.6	665	650	1040	17.0	<0.1	0.4	0.02	0.8	0.02	<0.0[illegible]
x̄	Site # RH16	2753	2640	8.19	776	107.4	8315	8258	12150	7510	188.35	248.94	0.069	2.35	2.22	1.30
x̄	Site # RH17	203	195	7.7	35	3.5	1630	1615	1950	1.5	4.4	7.6	0.52	2.4	0.04	0.02
x̄	Site # RH18	3410	4297	8.39	4003	248	14135	13641	17750	71000	424	560	0.18	0.100	4.20	1.31
x̄	Site # RH11	193	195	7.86	40.2	3.65	1142	1124	1597	13.5	2.43	3.44	0.30	1.69	0.06	0.02
	Prov Drinking Water Criteria	250						500				0.15		10.0		
	Prov. Water Quality Objectives (Protection of Aquatic Life)			6.5-8.5							*					

*Ammonia

Concentrations of un-ionized ammonia should not exceed 0.02 mg/L for the protection of aquatic life.

The percentages of un-ionized ammonia in aqueous ammonia solution for different temperature and pH conditions are listed below:

Temperature °C	pH 6.0	6.5	7.0	7.5	8.0	8.5	9.0	9.5	10.0
5	0.013	0.040	0.13	0.39	1.2	3.8	11	28.	56.
10	0.019	0.059	0.19	0.59	1.8	5.6	16.	37.	65.
15	0.027	0.087	0.27	0.86	2.7	8.0	22.	46.	73.
20	0.040	0.13	0.40	1.2	3.8	11.	28.	56.	80.
25	0.057	0.18	0.57	1.8	5.4	15.	36.	64.	85
30	0.081	0.25	0.80	2.5	7.5	20.	45.	72.	89

For example, at 20°C and pH 8.0, a total ammonia concentration of 0.5 mg/L would give an un-ionized concentration of 0.5 x 3.8/100 = 0.019 which is less than the un-ionized Objective of 0.02

* calculation of un-ionized ammonia = aqueous ammonia solution for different temp** and pH **temperature at 20°C

* from MOE Water Management booklet Table 1

Sw1	0.027
Sw2 RH-3	0.097
Sw3	0.028
Sw4 RH4	0.003
Sw5 RH2	0.002
Sw6 RH5	0.018
Sw7	0.004
R-16	7.157
R-17	0.167
R-19	0.092

compare these standards to 0.02

Surface Water: Redhill Creek-Parameter Means Compared to Provincial Drinking Water Criteria & Provincial Water Quality Objectives

	Site #	Total Iron	Zinc	Copper	Nickel	Lead	Cadmium	Chromium	Aluminum	Arsenic	Manganese
$\bar{x}$	Site #1	1.2	0.03	<0.01	<0.02	<0.03	<0.005	<0.02	0.93	0.002	
$\bar{x}$	Site #2 RH13	0.522	0.057	<0.013	<0.013	0.017	0.003	0.011	0.432	0.001	0.073
$\bar{x}$	Site #3	1.4	0.07	<0.01	<0.02	<0.03	<0.005	<0.02	1.2	0.002	
$\bar{x}$	Site #4 RH14	1.73	0.095	0.013	0.012	<0.017	<0.0026	0.013	0.073	0.002	0.075
$\bar{x}$	Site #5 RH12	0.55	0.021	0.016	0.009	<0.012	<0.002	0.007	0.578	0.002	0.060
$\bar{x}$	Site #6 RH15	0.94	0.024	0.010	0.013	<0.017	0.003	0.015	0.64	<0.001	0.665
$\bar{x}$	Site #7		<0.01	<0.01	<0.02	<0.03	<0.005	<0.02	<0.06	<0.001	
$\bar{x}$	Site # RH16	5.18	0.55	0.183	0.218	0.34	0.024	0.299	5.31		4.19
$\bar{x}$	Site # RH17	0.18	0.049	0.034	0.012	0.011	0	0.003	0.21		0.037
$\bar{x}$	Site # RH18	18.3	0.54	0.043	0.34	0.185	0.001	0.260	9.2		0.048
$\bar{x}$	Site # RH11	0.73	0.071	<0.011	<0.015	<0.025	<0.004	<0.015	0.697	<0.001	0.169
	Prov. Drinking Water Criteria	0.3	5.0	1.0		0.05	0.01	0.05		0.01	0.05
	Prov. Water Quality Objectives (Protection of Aquatic Life)	0.3	0.03	0.005	0.025	0.025	0.0002	0.1	0.1	0.1	

Surface Water: Redhill Creek Parameter Means Compared to Provincial Drinking Water Criteria & Provincial Water Quality Objectives

	Site #		Total Coliform	Background Count	Fecal Coliform	Fecal Streptococci	FC : FS Ratio	
Gmx̄	Site # 1							
Gmx̄	Site # 2	RH13	28086	381301	936	742	x̄	1.48
Gmx̄	Site # 3							
Gmx̄	Site # 4	RH14	35158	131467	2315	862	x̄	3.46
Gmx̄	Site # 5	RH12	4965	80959	344	600	x̄	0.64
Gmx̄	Site # 6	RH15	1300	56000	150	400	x̄	0.38
Gmx̄	Site # 7							
Gmx̄	Site #	RH16	8090	242997	337	807	x̄	1.25
Gmx̄	Site #	RH17	6000	100000	860	1160	x̄	0.74
Gmx̄	Site #	RH18	116190	9465728	1439	125698	x̄	0.02
Gmx̄	Site #	RH11	6220	36435	424	258	x̄	1.64
	Prov. Drinking Water Criteria		< 2		0			
	Prov Water Quality Objectives (Recreational Activities)		1000		100			

if the FC : FS ratio exceeds 4, the source is likely to be human in origin
if the FC:FS ratio is less than 0.7, the source is likely of non-hu[illegible] origin
if the FC:FS ratio is between 0.7 - 4, the source is likely to be a mixture

Table 2-5

Redhill Creek at Mount Albion Falls (RH 11)
(Mar-June)

Parameter	Results of 1978		Results of 1979		Results of 1980		Results of 1981		Comparison
	x̄	σn	x̄	σn	x̄	σn	x̄	σn	
Suspended Solids	14.8	14.1	14.3	6.4	18.5	10.9	18		I
Dissolved Solids	895	277	950	189	865	235	1124	298	I
BOD5	3.5	2.5	3.3	1.64	1.55	0.43	2.6	2.4	D
COD	41.5	9.9	34.5	14.2	15	3.3			D
Turbidity	11.1	9.9	12.5	7.2	14.3	7.0	.4	0.67	I
Chloride	157	40.5	163	22	124	28.9	200	27	I
pH	7.83	0.025	7.96	0.075	7.96	0.09	7.82	0.08	S
Total Iron	0.80	0.71	0.76	0.36	1.02	0.47	0.44	0.18	I
Conductivity	1255	348	1390	275	1193	252	1545	162	I
Total Kjeldhal N	2.64	1.27	3.58	1.87	1.86	0.52	1.55	0.76	I
Free Ammonia	1.86	1.21	2.6	1.57	1.09	0.46	0.63	0.74	I
Nitrite	0.36	0.43	0.148	0.11	0.08	0.04	0.22	0.34	S
Nitrate	1.57	0.54	1.14	0.64	1.95	0.64	2.44	4.05	I
Total Phosphorous	0.06	0.03	0.06	0.02	0.06	0.03	0.05	0.03	S
Soluble Phosphorous	0.014	0.021	0.008	0.007	0.02	0.01	0.03	0.04	I
Copper	0.12	0.004	0.015	0.005	< 0.01	0	[illegible]	[illegible]	
Cadmium	0.006	0.002	< 0.005	0	< 0.005	0			S
Mercury			< 0.02	0	< 0.025	0.005	[illegible]	0.02	
Nickel	0.025	0.58	< 0.02	0	< 0.02	0	< 0.004	[illegible]	
Lead	< 0.03	0	< 0.03	0	< 0.03	0	[illegible]	0.01	
Zinc	0.058	0.044	0.06	0.04	0.08	0.09	[illegible]	[illegible]	I
	Gm x̄	log	Gm x̄	log	Gm x̄	log	Gm x̄	log	
Total Coliforms	4,600		2,230	3.35	13,941	4.14	8326	3.92	I
Background Colonies	51,000		24,790	4.39	66,225	4.82	53488	4.72	I
Fecal Coliform	130		231	2.36	332	2.52	709	2.85	I
Fecal Streptococci	90		126	2.10	427	2.63	462	2.66	I
FC/FS Ratio	1.4		1.83		0.78		1.53		S

Comparison trend from 1978-1981
I increasing
S similar
D decreasing

Table 2-6 Redhill Creek at Mount Albion Rd. ([illegible])

Trends since closure date - October [illegible]
(taken from Redhill Creek graphs)

Parameter	trend
Chlorides	I
Alkalinity	I
BOD	I
Total Solids	I
Dissolved Solids	I
Conductivity	I
Sulphates	S
Filtered Ammonia	D
Total Kjeldhal	D
Filtered Nitrate	I
Total Iron	D
Zinc	I
Lead	D
Aluminum	D
Fecal Coliform: Fecal Streptococci	I
Fecal Coliforms	I
Fecal Streptococci	I

trend

I	increasing
S	similar
D	decreasing

Table [illegible] Redhill Creek [illegible]

Long Term Monitoring

B C # / SITE: REDHILL CREEK
SAMPLE POINT: MOUNTAINBROW BLVD ON ALBION FALLS
STATION TYPE: RIVER

MAJOR BASIN GREAT LAKES
MINOR BASIN LAKE ONTARIO
TERM STREAM REDHILL CREEK

STATION 09-0201-004-02

STORET CODE: 02
004
4620

STN NO. 4 LAT. LONG. U T M: 17 0595850.0 4783500.0 4 REGION: 02 MILEAGE: 6.40

SAMP DTE HOUR DY MO YR UNT	STN DIST FEET	STN BRG	SAMP DEPTH MTRS	PJ	931 SAMPLE NO	901 SEQ	80 TOTAL COLIFORM MF/100ML	83 BACKGRD COUNT MF/100ML	81 FECAL COLIFORM MF/100ML	84 M F ENTER. MF/100ML	805 WATER TEMP. DEG C	3 DISS. O2 MG/L	1 5-DAY BOD MG/L	33 TOTAL P MG/L
23 01 79 0940			.3		48325	4	8000 A	13000.	2000. A	1000 A	1.0	12.0	4.2	0.040
23 02 79 0945			.3		48378	4	1000 A	11000E+1	200. A	1200	1.0	12.3	4.0	0.144
26 03 79 0920			.3		48418	3	4000 A	14000.	100. A	300. A	2.5	13.2	1.8	0.042
03 05 79 1015			.3		48455	6	2000. A	33000.	700.	130.	7.9	9.4	3.2	0.037
17 05 79 0930			.3		48511	5	1020 C	18300	120.	50. A	13.2	9.6	2.8	0.053
06 06 79 1210			.3		48578	6	1700. C	67000.	340.	130.	16.2	9.1	5.6	0.058
16 07 79 0930			.3		48901	6 9 0	2000. C	22000	210.	30 A	16.2	5.9	5.2	0.075
27 08 79 1100			.3		48926	6	87000. C	30000E+1	4900.	1500. E	19.0	7.2	3.4	0.134
11 09 79 0910			.3		48975	6	37000	13000E+1	2700.	1500.	16.8	5.4	5.0	0.053
03 10 79 0940			.3		49743	5	31000	16000E+1	4900.	4500.	10.0	7.8	7.0	0.135
21 11 79 0915			.3		49773	6	4700	31000.	400. A	100. L	8.0	6.8	6.8	0.063
12 12 79 0945			.3		49836	6	4100.	15000.	230.	280.	8.9	8.3	6.0	0.060
MAXIMUM							87000.	30000E+1	4900.	4500.	19.0	13.2	7.0	0.144
AVG OR GEOM MN (*)							5344.*	42766.*	570.*	342.* E	10.0	8.9	4.7	0.081
MINIMUM							1000.	13000.	100.	30.	1.0	5.4	1.8	0.037
NO OF SAMPLES							12	12	12	12	12	12	12	12

SAMP DTE HOUR DY MO YR UNT	STN DIST FEET	STN BRG	SAMP DEPTH MTRS	PJ	34 FILTERED REACTIVE P MG/L	19 FILTERED AMMONIA MG/L	20 TOTAL KJELDAHL MG/L	21 FILTERED NO2-N MG/L	22 FILTERED NO3 N MG/L	17 INORGNC N MG/L	16 TOTAL ORGNC N MG/L	23 TOTAL N MG/L	5 TOTAL SOLIDS MG/L	6 SUSP. SOLIDS MG/L
23 01 79 0940			.3		0.024	5.880	6.950	0.038	1.240	7.158	1.070	8.220	1251.0	38.0
23 02 79 0945			.3		0.032	3.160	3.700	0.074	1.730	4.964	0.540	5.504	1201.0	32.0
26 03 79 0920			.3		0.017	0.873	1.560	0.033	2.090	2.996	0.687	3.683	732.0	10.0
03 05 79 1015			.3		0.002	2.870	3.700	0.072	0.758	3.700	0.830	4.530	984.0	11.0
17 05 79 0930			.3		0.008	2.050	3.000	0.233	0.730	3.010	0.950	3.960	841.0	7.0
06 06 79 1210			.3		0.003	4.400	6.050	0.255	0.995	5.650	1.450	7.300	1198.0	21.0
16 07 79 0930			.3		0.007	2.223	3.787	1.500	2.950	6.670	1.560	8.230	1343.0	16.0
27 08 79 1100			.3		0.007	2.163	3.330	0.250	1.190	3.610	1.170	4.780	892.0	88.0
11 09 79 0910			.3		0.004	4.300	5.100	0.400	1.780	6.480	0.800	7.280	993.0	12.0
03 10 79 0940			.3		0.028	1.930	2.350	0.276	1.270	3.046	0.830	3.898	631.0	43.0
21 11 79 0915			.3		0.011	2.900	6.750	0.150	1.950	6.000	2.850	8.850	1247.0	14.0
12 12 79 0945			.3		0.009	2.652	3.600	0.134	2.310	4.996	0.950	5.946	1208.0	28.0
MAXIMUM					0.032	5.880	6.950	1.500	2.950	7.158	2.850	8.850	1343.0	88.0
AVG OR GEOM MN (*)					0.013	3.015	4.198	0.315	1.574	4.875	1.141	6.016	1035.3	24.8
MINIMUM					0.002	0.873	1.560	0.033	0.730	2.996	0.540	3.683	631.0	7.0
NO OF SAMPLES					12	12	12	12	12	12	12	12	12	12

SAMP DTE HOUR DY MO YR UNT	STN DIST FEET	STN BRG	SAMP DEPTH MTRS	PJ	7 DISS. SOLIDS MG/L	14 COND 25C UMHOS	15 TURB FORMAZIN UNITS	56 CHLORIDE MG/L	60 SULPHATE MG/L	57 TOT ALK AT LAB MG/L	55 PH AT LAB	25 PHENOLS UG/L	200 TOTAL IRON MG/L	68 COLOUR HAZEN UNITS
23 01 79 0940			.3		1213	1730	32.00	223.0	357.0		7.94	2.0	2.200	10
23 02 79 0945			.3		1169	1850	17.00	425.0	176.0		7.74	3.0	1.600	28
26 03 79 0920			.3		714	1050	22.00	135.0	144.0		8.04	1.0L	1.200	16
03 05 79 1015			.3		973	1430	7.23	170.0	292.0		7.82	1.0	0.440	33
17 05 79 0930			.3		834	1360	6.62	160.0	250.0		8.01	1.0L	0.480	41
06 06 79 1210			.3		1175	1720	14.00	188.0	295.0		7.88	2.0	0.900	43
16 07 79 0930			.3		1327	1620	5.60	228.0	450.0	152	7.68	1.0L	0.790	45
27 08 79 1100			.3		641	915	43.00	113.0	171.0	107	7.10	2.0	2.800	17
11 09 79 0910			.3		931	1410	10.00	143.0	326.0	180	7.84	1.0	0.590	41
03 10 79 0940			.3		588	950	50.00	103.0	193.0	178	7.71	1.0	2.500	95
21 11 79 0915			.3		1233	1800	11.00	193.0	424.0	269	7.66	1.0L	0.790	47
12 12 79 0945			.3		1181	1690	14.60	180.0	351.0	249	7.98	1.0L	1.100	31
MAXIMUM					1327	1850	50.00	425.0	450.0	269	8.04	3.0	2.800	95
AVG OR GEOM MN (*)					1011	1472	19.37	183.2	272.2	180	7.73	1.40	1.284	37
MINIMUM					588	915	5.60	103.0	144.0	107	7.10	1.0	0.440	10
NO OF SAMPLES					12	12	12	12	12	6	12	12	12	12

SAMP DTE HOUR DY MO YR UNT	STN DIST FEET	STN BRG	SAMP DEPTH MTRS	PJ	41 COD MG/L	355 TOTAL ARSENIC MG/L	235 TOTAL MERCURY UG/L	203 TOTAL ALUMINUM MG/L	221 TOTAL CHROMIUM MG/L	225 TOTAL COPPER MG/L	229 TOTAL LEAD MG/L	215 TOTAL CADMIUM MG/L	249 TOTAL ZINC MG/L	201 TOTAL MN MG/L
23 01 79 0940			.3		48	0.001L	0.020L	2.200	0.020	0.010	0.030L	0.005	0.070	0.264
23 02 79 0945			.3		41	0.001	0.020L	1.100	0.020	0.010L	0.040	0.005L	0.060	0.300
26 03 79 0920			.3		33	0.001	0.02 L	0.24	0.02 L	0.01 L	0.03 L	0.005L	0.09	0.118
03 05 79 1015			.3		43	0.002	0.020L	0.220	0.020L	0.020	0.030L	0.005L	0.030	0.176
17 05 79 0930			.3		34	0.001L	0.02 L	0.43	0.02 L	0.01	0.08	0.005L	0.04	0.154
06 06 79 1210			.3		52	0.001L	0.02 L	0.33	0.02 L	0.01 L	0.06	0.005L	0.02	0.300
16 07 79 0930			.3		42	0.001L	0.020L	0.330	0.020L	0.020	0.030L	0.005L	0.080	0.102
27 08 79 1100			.3		34	0.001L	0.030L	2.300	0.030	0.010L	0.030L	0.020	0.050	0.180
11 09 79 0910			.3		43	0.001L	0.020L	0.400	0.020L	0.010L	0.030L	0.005L	0.060	0.098
03 10 79 0940			.3		56	0.001L	0.020L	2.100	0.020L	0.010L	0.030L	0.005L	0.060	0.136
21 11 79 0915			.3		54	0.002	0.030L	0.510	0.020L	0.010L	0.030L	0.005L	0.060	0.210
12 12 79 0945			.3		34									0.242
MAXIMUM					56	0.002	0.030	2.300	0.030	0.020	0.08	0.020	0.09	0.300
AVG OR GEOM MN (*)					42	0.0013	0.0223	0.978	0.0218	0.0120	0.0390	0.0080	0.057	0.190
MINIMUM					33	0.001	0.020	0.220	0.020	0.010	0.030	0.005	0.02	0.098
NO OF SAMPLES					12	11	11	11	11	11	11	11	11	12

SAMP DTE HOUR DY MO YR UNT	STN DIST FEET	STN BRG	SAMP DEPTH MTRS	PJ	218 TOTAL NICKEL MG/L	217 TOTAL COBALT MG/L	272 AVAILABLE CYANIDE MG/L CN
23 01 79 0940			.3		0.020L	0.020L	0.01L
23 02 79 0945			.3		0.020L	0.020L	0.01
26 03 79 0920			.3		0.02 L	0.02 L	0.01L
03 05 79 1015			.3		0.020L	0.020L	0.02
17 05 79 0930			.3		0.01 L	0.02 L	0.01L
06 06 79 1210			.3		0.02 L	0.02 L	0.01L
16 07 79 0930			.3		0.020L	0.020L	0.01L
27 08 79 1100			.3		0.020L	0.020L	0.01L
11 09 79 0910			.3		0.020L	0.020L	0.07
03 10 79 0940			.3		0.020L	0.040	0.00L
21 11 79 0915			.3		0.020L	0.020L	0.01L
MAXIMUM					0.020	0.040	0.07
AVG OR GEOM MN (*)					0.0190	0.0243	0.023
MINIMUM					0.01	0.020	0.00
NO OF SAMPLES					11	11	11

[illegible]
PPh

X
0.05
0.1
X

STATION NO: 09-0001-004 02

Table 2-7

STREAM REDHILL CREEK

DATE / RAMETER	JAN 28	FEB 25	MAR 26	APR 29	MAY 15	JUN 11	JUL 6	JUL 7	JUL 16	AUG 18
BMISSION No.	28321	28356	28412	28483	28519	28563	80036	80037	28613	28649
IME OF DAY	945	940	910	925	930	1020	1200	0015	945	1010
MPERATURE	1.3	1.0	5.5	7.5	9.0	13.0	24.0	22.0	24.0	22.0
ISSOLVED OXYGEN	13.2	12.0	11.6	12.2	11.0	10.1	11.0	11.2	9.0	9.1
TREAM CONDITION	4	4	3	3	6	69	8	8	60	690
OTAL COLIFORM	4200	3800	7300	150000	7500	4600			4500	100
ACKGROUND COLONIES	5000	17000	17000	500000	31000	73000			26000	45000
ECAL COLIFORM	430	460	50	1140	28	700			100	40
1.F. ENTER.	140	220	450	2400	140	220			76	30
TAL PHOSPHOROUS	.045	.073	.070	.100	.027	.040	.041	.055	.015	.025
OTAL KJELDAHL	3.78	1.95	1.63	1.30	1.80	2.70	2.72	2.90	2.30	2.61
ILTERED AMMONIA	3.00	1.87	.85	.530	1.19	1.77	2.06	1.80	1.34	1.73
ILTERED NITRITE	.050	.056	.065	.040	.078	.150	.680	.840	1.15	.500
ILTERED NITRATE	1.60	1.89	2.93	2.11	1.27	1.50	1.77	1.61	2.15	2.25
LTERED REACTIVE P.	.011	.021	.025	.031	.002	.006	.007	.004	.001	.010
ULPHATE	333	317	188	161	282	401			559	550
HLORIDE	180	178	113	82	146	155			182	190
OTAL IRON	1.0	.94	1.2	1.7	.48	.70			.21	.18
ANGANESE	.176	.175	.083	.112	.152	.120			.034	.074
H AT LAB	8.03	8.13	8.11	7.87	7.93	7.92	7.89	7.81	7.73	7.74
COLOUR	20	13	26	34	32	15			27	32
URBIDITY	16	16	19	23	5.8	9.2			2	2.4
ONDUCTIVITY	1440	1480	1020	900	1300	1550	1800	1800	1850	1850
OTAL SOLIDS	1076	1067	748	623	937	1225			1568	1517
USPENDED SOLIDS	15	17	19	36	8	11			3	3
ISSOLVED SOLIDS	1061	1050	729	587	929	1214			1565	1514
LCUL. DISS. SOLIDS										
ENOLS	<1	1	<1	<1	<1	<1			<1	1
BOD5	6.8	1.8	1.4	2.2	1.0	1.6			2.2	2.0
OD	56	10	18	14	<10	18			40	34
OTAL ALKALINITY	241	212	159	174	220	225			165	189
pH in Field									7.5	7.75
HROMIUM	.04	<.02	<.02	<.02	<.02	<.02			.03	<.002
LUMINUM	.89	.76	1.2	2.1	.20	.46			.40	.076
ZINC	.09	.06	.23	.05	.03	.02			.02	.009
COPPER	.01	.02	<.01	<.01	<.01	<.01			.01	.005
NICKEL	<.02	<.02	<.02	<.02	<.02	<.02			.03	.005
EAD	<.03	<.03	<.03	<.03	<.03	<.03			<.03	<.003
CADMIUM	<.005	<.005	<.005	<.005	<.005	<.005			<.005	.0007
COBALT	<.02	<.02	<.02	<.02	<.02	<.02			<.02	<.002
RSENIC	<.001	.001	.001	.002	<.001	.001			<.001	<.001
YANIDE	<.01	<.01	<.01	<.01	<.01	<.01			<.01	<.01
MERCURY	<.02	<.02	<.02	<.02	<.03	<.03			<.04	.60
PCB	X	X	X	X	X	X			.03	X

1980

STATION NO: 09-0001-004-02

STREAM REDHILL CREEK

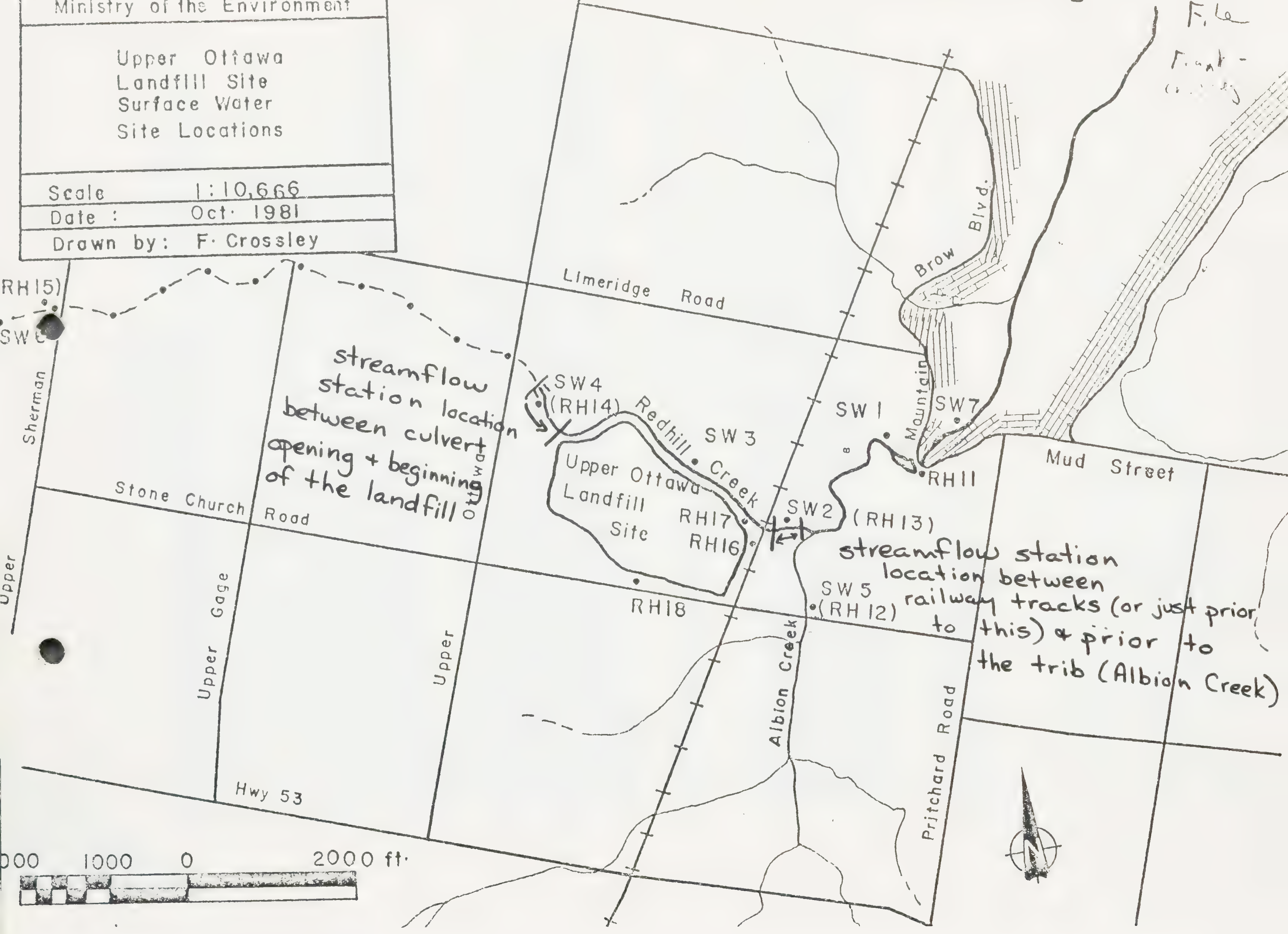
DATE / PARAMETER	SEP 25	OCT 27	NOV 20	DEC 18
SUBMISSION NO.	28707	28750	28777	28831
TIME OF DAY	1115	945	950	1025
TEMPERATURE	17.0	7.5	4.0	0.5
DISSOLVED OXYGEN	10.1	11.6	10.0	11.2
STREAM CONDITION	6	6	6	4
TOTAL COLIFORM	2700	5900	3100	1300
BACKGROUND COLONIES	G 15000	73000	12000	6700
FECAL COLIFORM	80	40	160	90
M.F. ENTER.	120	G 3000	160	50
TOTAL PHOSPHOROUS	.037	.054	.037	.025
TOTAL KJELDAHL	3.07	6.97	3.4	5.05
I TERED AMMONIA	.004	5.7	3.4	4.10
FILTERED NITRITE	.001	.075	.12	.050
FILTERED NITRATE	2.20	1.0	1.28	1.45
FILTERED REACTIVE P.	<.001	.003	.004	.008
SULPHATE	444	730	515	485
CHLORIDE	152	225	142	197
TOTAL IRON	.54	1.1	.84	.70
MANGANESE	.163	.276	.182	.21
pH AT LAB	7.83	8.08	7.89	8.03
COLOUR	28	39	28	24
TURBIDITY	7	13	8.9	15
CONDUCTIVITY	1450	2200	1950	1900
TOTAL SOLIDS	1051	1605	1384	1409
SUSPENDED SOLIDS	10	21	15	12
DISSOLVED SOLIDS	1041	1584	1369	1397
CALCUL. DISS. SOLIDS				
, HENOLS	< 1	< 1	1	< 1
BOD5	2.2	5.2	3.0	1.8
COD	14	59	58	53
TOTAL ALKALINITY	143	241	221	215
pH IN FIELD	7.55	7.5	7.6	
CHROMIUM	<.002	.005	.001	.002
ALUMINUM	.36	.71	.35	.47
ZINC	.009	.052	.029	.071
COPPER	.005	.012	.006	.004
NICKEL	.003	.006	.004	.008
LEAD	<.003	<.003	.003	<.003
CADMIUM	<.0002	<.0002	<.0002	<.0002
COBALT	<.002	<.002	<.0005	<.0005
ARSENIC	<.001	<.001	<.001	<.001
CYANIDE	<.01	<.01	<.01	<.01
MERCURY	<.03	<.02	<.04	
PCB'S	X			

TATION NO. :

DATE / PARAMETER	JAN. 26	FEB. 9	MAR. 25	APR. 30	MA 26	X's	σn's (for accumulated data 1979-81)
FIELD NUMBER			000006	000030	00001[illegible]		
SAMPLE NUMBER	35321	35369	38427	385[illegible]0	305[illegible]		
TIME	1115	935	910	905	951		
TEMPERATURE	3.5	1.4	4.5	10.0	15.[illegible]		
DISSOLVED OXYGEN	16.6	16.0	11.0	12.4	6.[illegible]		
pH IN FIELD		7.8		8.0	7.5		
STREAM CONDITION	6	4	5	6	6		
TOTAL COLIFORMS	[illegible]	12000	37200	8700	2200	6220 Gmx̄	3.79 log
BACKGROUND COLONIES	32000	26000	12000	28000	8400	36435	4.56
FECAL COLIFORMS	130	2020	2040	16	190	258	2.41
FECAL STREPTOCOCCI	550	450	760	140	23	135	2.13
PSEUDO. AERUG.			[illegible]	40 G	30		
PSEUDO. BCKGRD.			[illegible]	10 G	36		
BOD	3.4	4.5	2.12	1.12	6.6	3.65	1.91
TOTAL PHOSPHORUS	.084	.043	.022	.036	.041	0.06	0.03
FILTERED REACTIVE P.	.032	.016	.007	.007	.028	0.012	0.010
FILTERED AMMONIA N.	2.45	4.85	.181	.680	.006	2.43	1.53
TOTAL KJELDAHL N.	4.34	5.60	2.61	1.43	.74	3.44	1.68
FILTERED NITRITE N.	1.07	.037	.810	.045	.005	0.30	0.38
FILTERED NITRATE N.	1.63	.970	.890	2.37	3.75	1.69	0.57
NITRITE + NITRATE			1.70	2.42	3.75		
DISSOLVED ORGANIC C.							
SUSPENDED SOLIDS	10	8	6	7	5	18	
DISSOLVED SOLIDS	1383	1755	1120	897	1298	1124	298
CALCULATED DISS. SOLIDS							
CONDUCTIVITY	2050	2650	1650	1280	1700	1597	388
TURBIDITY	7	43	13.8	4.7	3.0	13.5	11.4
CHLORIDES	319	468	233	158	210	193	83
SULPHATES	336	400	310	226	381		
TOTAL ALKALINITY	191	233	198	180	201	195	40
pH AT LAB	7.90	7.83	7.84	7.89	7.69	7.86	0.19
PHENOLS	<1	<1	<1	<1	<1	<1.18	0.46
TOTAL IRON	.64	.46	.36	.37	.29	0.99	
COLOUR	14	19	12	15.7	24.2		
CHEMICAL OXYGEN DEM.	78	74				40.2	19.0
HARDNESS			443	471	512		
CALCIUM			118	112	134		
MAGNESIUM			36	32	43		
SODIUM			122	89	115		
POTASSIUM			7.10	5.40	9.0		
ARSENIC	<.001	<.001				<0.001	0.0003
MERCURY	<.05	<.04	<.03	<.05	<.08		
ALUMINIUM	.520	.059	.160	.22	.130	0.697	0.669
CHROMIUM	.002	<.001	<.002	<.002	<.002	<0.015	0.011
COPPER	.027	.004	.012	.006	.008	<0.011	0.005
LEAD	.008	.004	.010	<.002	.043	<0.025	0.018
CADMIUM	.002	.007				<0.004	0.004
ZINC	.250	.036	.140	.140	.081	0.071	0.061
MANGANESE	.23	.232	.168	.088	.148	0.169	0.068
[illegible]	.009	.004	.007	.003	<.002	<0.015	0.008

Possible Streamflow Locations

File
Frank -



Ministry of the Environment

Upper Ottawa
Landfill Site
Surface Water
Site Locations

Scale 1:10,666
Date : Oct. 1981
Drawn by: F. Crossley

streamflow station location between culvert opening + beginning of the landfill

streamflow station location between railway tracks (or just prior to this) + prior to the trib (Albion Creek)

SEMINAR: TOPIC

Monitoring Wells

Groundwater monitoring wells are used to monitor groundwater quality and quantity in the following applications:

1) to assess migrationof lagoon effluent to the groundwater.
2) to assess migration of contamination from industrial disposal sites eg: tailings areas, settling basins,etc. and spill sites.
3) to monitor groundwater level variations associated with interference investigations.
4) to assess leachate migration from sanitary landfill operations.

Monitoring well systems serve as an early warning system to determine the extent of migration of contamination and also provide a source of information to determine the effectiveness of various protective systems.

Monitoring systems are designed to determine the location of the boundary between uncontaminated and contaminated water and the degree of movement of the boundary. Plans for monitoring should consider such aspects as approximate geometry of the contamination plume and uncontaminated zone, the potential for advancement of a contamination front towards existing and potential water supplies, nature of the contaminant including alteration within the soil boundaries as well as nature and permeability of the overburden material and hydrogeologic framework.

Following an early estimate priority may be given to placing one or more wells in what is considered to be the early precusor zone (ie: zone in which the contamination is detectable but quality of water is not seriously objectionable. The earliest aspect of contamination may be detected by small quantities of the contaminant or by some constituent that travels in the water at a faster rate than the contaminant and that may be a forewarner of the contamination eg: conductivity, dissolved salts, total dissolved solids, etc. Where contamination from waste sites undergo attenuation by sorption or some decay mechanism, the contaminants may either never reach the early precursor zone or they may reach it long after the water that original carried it reaches the zone; in some cases, such as those involving sewage wastes, an increase in chloride or hardness content of the water would be the early precusor.

[illegible] for additional well locations

To optimize the performance of a groundwater monitoring system the following is necessary:

direction of contaminant plume NE, E towards Albion Falls

1) strategic location of monitoring wells. ie: perpendicular to the inferred direction of the contaminant movement near the boundary of the early precursor zone and the uncontaminated zone.
2) proper depth of installation to monitor the groundwater resource of concern.
3) proper construction ie: to exclude surface run-off input and to minimize plugging by silt, etc.
4) standardize sampling procedures.

Location of Monitoring Wells:

Where monitoring wells are required, their position will depend

sedimentary bedrock - dolostone

primarily upon local hydrogeology and groundwater use. For this reason design of a monitoring well system is considered site specific. Groundwater flow direction and gradient, overburden nature and diversion of groundwater interacting with bedrock as well as the fracture development and permeable nature of the bedrock are prime considerations.

explain drawbacks (limits of wells) in fractured bedrock (dolostone) however still an indicator

? multiple level sampling device (J Cherry) vs. well

Monitoring Well Depth:

Proper depth of installation of the monitoring wells may become very complex in multiple aquifer environments but in the common unconfirmed aquifer situations it is necessary only to consider the maximum annual fluctuation of the groundwater table to determi the depth at which the monitoring well may be installed to ensure that the watertable never lowers to a level which will not afford convenient monitoring.

Monitoring Well Construction:

Construction of monitoring wells should combine the advantages of sensitivity for recording water levels while not sacrificing convenience for collecting samples using a variety of sampling techniques. It is constructed of non-metallic materials so as not to influence gorundwater quality analyses. Proper sealing of the area around the well casing is important particularly in high permeability overburden conditions to eliminate possible movement of contaminated surface water down the sides of the casing. In locations where it is not possible to keep the monitoring wells under surveillance it may be necessary to install a secure cover over the monitoring well to avoid damage and/or inclusion of foreign matter into the well.

A typical monitoring well design would be as follows:

1) 4" A.B.S. casing extending 5 ft. below the watertable in low waterlevel conditions (ie: summer months).
2) lower 6 ft. perforated and covered with glass fibre to prevent plugging by silt.
3) 1½ to 3 ft. of capped casing above ground surface and sealed to prevent entrance of surface runoff ie: bentonite clay or concrete sealer.
4) installation of 6" steel casing secured into the ground and capped to provide physical protection of the well and prevent inclusion of foreign matter.

Sampling Procedure:

To minimize sampling and analyses inconsistencies the following standardized sampling procedure would be recommeded:

1) record static water level and depth of water contained in casin
2) remove at least twice the volume of water contained in the monitoring well prior to sampling. [illegible] fully removed all the volume [illegible] contained in the [illegible] well [illegible] time

? is this being done?

The following table indicates the number of gallons of water contai ed in each foot of well casing:

* This is important or else the sample will not be considered

Sampling devices → remain consistent
preferred technique → stainless steel bailers
lined ~~with teflon~~ → expensive
copper bailers → cheap, easy to make, disposable, disadvantage copper may be stripped off as well as lead & iron at soldered joints

Inside Diameter of Casing (inches)	Imperial Gallons of Water per foot of Casing
2	0.14
4	0.53
5	0.86
6	1.22
7	1.67
8	2.13

3) samples should be collected periodically from the facility being monitored where applicable ie: industrial seepage lagoons and sanitary lagoons etc. for comparison purposes.

4) submission of analyses parameters should be consistent and relevant to the facilities being monitored, ie: landfill site - chlorides, conductivity, heavy metals etc. sanitary lagoons, nitrate species, phosphates, total dissolved solids, etc.

5) for relevancy of interpretation specified sampling intervals should be strictly adhered to.

Recommended minimum sampling 4 times per year

Sampling intervals should be shorter (ie: twice per month) upon initiation of a monitoring programme to provide a more comprehensive data basis. When an adequate base has been established the sample interval may be lengthened (ie: o[illegible] month). When feasible the monitoring should be initiated prior to the establishment of waste disposal to provide background water quality analyses.

April, late July or early August, October + December

Background water quality data should also be collected from all domestic wells in the vicinity, ie: ½ mile radius.

General System Design:

All groundwater monitoring systems should incorporate a control water quality monitoring point for a comparative interpretation of sample analyses results.

(BH1 + BH12)

The number and location of adjacent monitoring wells downgradient from the installation to be monitored will be determined from local hydrogeologic conditions (ie: groundwater flow-net, gradients groundwater divides, etc.).

At all times the strategic location of monitoring wells must be related to the information required from them ie: monitoring migrating contamination front from specific cells of a sanitary lagoon, etc.

In this case, it would be hard to do

The remote monitoring well or wells are located at a greater distance downgradient from the site and are designed to supply additional information on the geometry and extent of a migrating contamination plume ie: chemical gradients between adjacent monitoring wells and remote well or wells and a secondary warning of the migration of the contamination front in the event that it surpasses the adjacent monitoring well system.

because of the elevation difference. However, the escarpment face can be used as an advantage to monitoring through

It is difficult to generalize on the design of the monitoring well system as design is always site specific. The location of monitoring wells must be strategic and utility of the data to be obtained must always be kept in mind to optimize the value of the system.

site closed

Since groundwater flow and contaminant migration is a dynamic system the need for further monitoring may arise with future site expansion ie: additional lagoon cells, etc. An adequate monitoring well system can always be designed through the use of the three catagories of monitoring wells ie: control (background) well,adjacent well(s) and remote well(s).

In this Region when we recommend a monitoring well design we attempt to justify the use of each and every monitoring point as well as recommend a standardize sampling procedure.

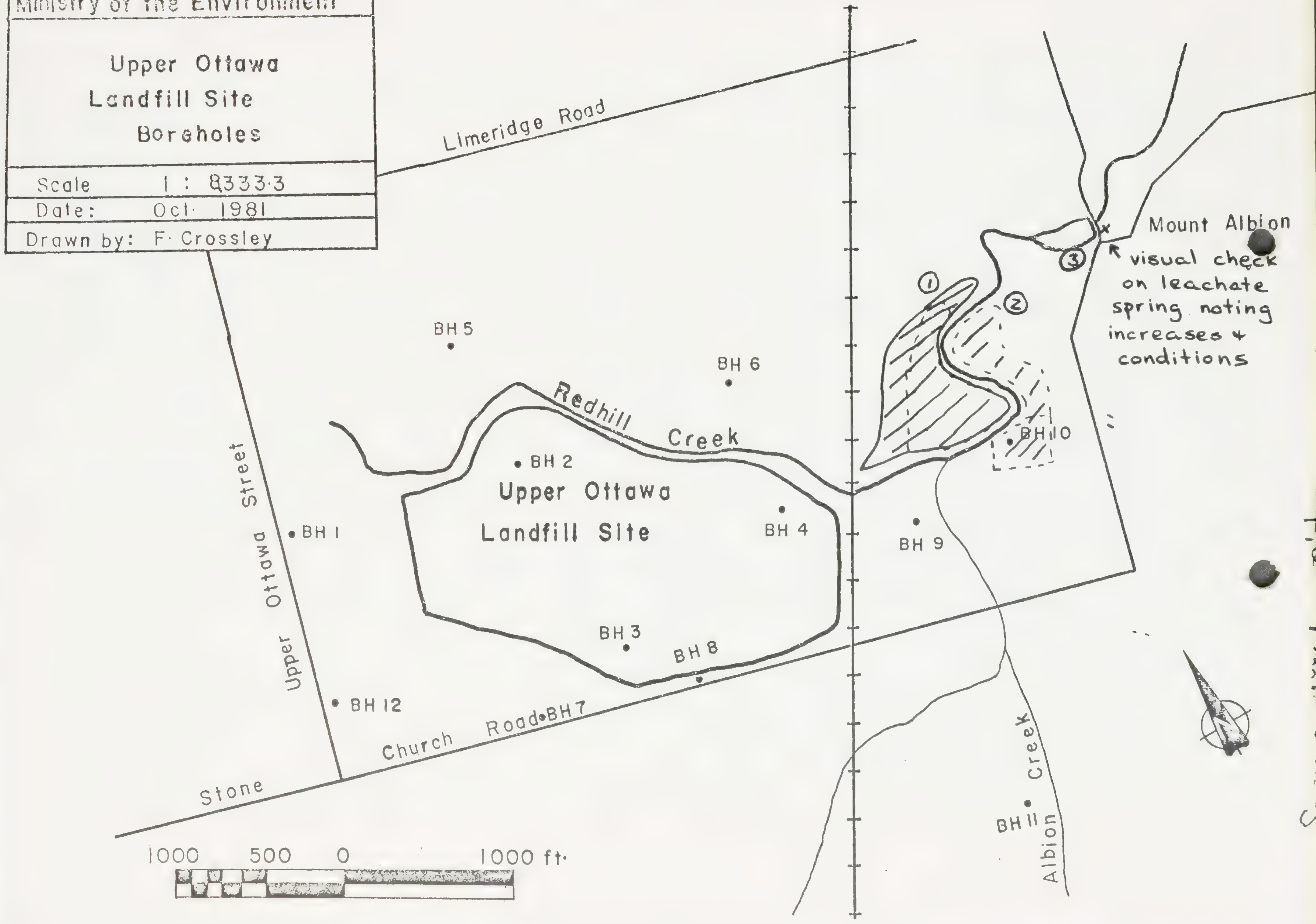
Prepared by:

Clyde Hammond

Clyde Hammond
Regional Hydrogeologist
Northeastern Region

/jmh
c.c. TS 31-05

Possible Borehole Locations



visual check on leachate spring noting increases + conditions

Groundwater at Upper Ottawa Landfill Site: Parameter Means Compared to Provincial Drinking Water Criteria

Site	#	PPT PCB	HCB	α BHC	β BHC	Lindane	Hepta Chlor	Hept. Epoxide	Endosulfan I	Endosulfan II	Aldrin	Dieldrin	Endrin	ppDDE	opDDT	ppDDD	ppDDT	α Chlordane	γ Chlordane	Mirex	PPB Phenols
BH #1	P#1	<20																			1.7
BH #2	P#1																				298
BH #2	SP#2																				340
BH #4	P#1																				65
BH #4	SP#2																				
BH #6	P#1	<20																			2.7
BH #7	P#1	56																			[illegible]
BH #8	P#1	<20																			
BH #9	P#1	X	X	0.008	X	X	X		X	X	X	0.030	0.007	X	X	X	X	X	X	X	1.5
BH #9	SP#2	<20																			1.5
BH #11	P#1	X	X	0.020	0.002	0.001	X		X	X	X	0.030	0.008	X	X	X	X	X	0.002	X	14.5
BH #11	SP#2	26																			1
BH #12	P#1	<20																			<1
MOE Drinking Water Quality Criteria		10 ppb				4.0	3.0				0.70		0.20	30				7			1 ppb

UPPER OTTAWA STREET LANDFILL SITE - HAMILTON
PCB AND ORGANOCHLORINE PESTICIDES (M.O.E. 1980)

(All Data in ppb)

Contaminant	Borehole 9	Borehold 11	SW1 (Below)	SW4 (Above)	Leachate 1	Leachate 2	MOE Guidelines PAL *	Health and Welfare Canada Drinking Water**	Detection Limits
PCB	x	x	x	x	.20	.60		***	.020
HCB	x	x	x	x	.02	.02			.001
α BHC	.008	.020	x	.001	x	x			.001
β BHC	x	.002	x	x	x	x			.001
Lindane	x	.001	x	x	x	x	.01	4.0	.001
Heptachlor	x	x	x	x	x	x	.001	3.0	.001
Hept. Epoxide	-	-	-	-	x	x			.001
Thioden I	x	x	x	x	x	x	.003		.001
Thioden II	x	x	x	x	x	x			.001
Aldrin	x	x	x	x	x	x	.001	.70	.001
Dieldrin	.030	.030	x	x	x	x			.001
Endrin	.007	.008	x	x	x	x	.002	.20	.001
pp DDE	x	x	x	x	x	.010	.003	30.	.001
op DDT	x	x	x	x	x	x			.005
pp DDD	x	x	x	x	x	.010			.005
pp DDT	x	x	x	x	x	x			.005
α Chlordane	x	x	x	x	x	x		7.	.001
γ Chlordane	x	.002	x	.001	x	x			.001
Mirex	x	x	x	x	x	x			.005

x = Below limit of detection
- = Not tested

* = MOE Provincial Water Quality Objectives (Protection of Aquatic Life)
** = Maximum allowable concentration
*** = MOE suggested Drinking Water Guidelines for PCB = 3 ppb

Surface Water: Redhill Creek Parameter Means Compared to Provincial Drinking Water Criteria & Provincial Water Quality Objectives

Site #	ppb PCB	HCB	α BHC	βBHC	Lindane	Hepta Chlor	Hept. Epoxide	Thiodan I	Thiodan II	Aldrin	Dieldrin	Endrin	ppDDE	opDDT	ppDDD	ppDDT	α Chlordane	γ Chlordane	Mirex	ppb Phenols
$\bar{x}$ Site #1	x	x	x	x	x	x		x	x	x	x	x	x	x	x	x	x	x	x	<1
$\bar{x}$ Site #2 RH13	<20																			1.7
$\bar{x}$ Site #3																				<1
$\bar{x}$ Site #4 RH14	<20	x	0.001	x	x	x		x	x	x	x	x	x	x	x	x	x	0.001	x	1.7
$\bar{x}$ Site #5 RH12																				<1
$\bar{x}$ Site #6 RH15																				<1
$\bar{x}$ Site #7																				<1
$\bar{x}$ Site # RH16																				75.5
$\bar{x}$ Site # RH17																				1.0
$\bar{x}$ Site # RH18																				5.0
$\bar{x}$ Site # RH11	X																			<1.18
Prov. Drinking Water Criteria	[illegible] ppb				4.0	3.0				0.70		0.20	30.0				7.0			1.0 ppb
Prov. Water Quality Objective (Protection of Aquatic Life)					0.1	0.001		0.003		0.001		0.02	0.003							1.0 ppb

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17021 – BLACK / NOIR – BG1703
17028 – RED / ROUGE – BF1703
17024 – GREY / GRIS – BD1703
17025 – GREEN / VERT – BP1703
17022 – BLUE / BLEU – BU1703

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